INTIMAL CHANGES IN THE SMALL VESSELS OF SMOKERS: A STUDY OF MYOCARDIUM AND KIDNEY

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1979

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INTIMAL CHANGES IN THE SMALL VESSELS OF SMOKERS: A STUDY OF MYOCARDIUM AND KIDNEY

by

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ABSTRACT

Cigarette smoke has been implicated as a cause of intimal thickening in the small vessels of the myocardium. Renal vascular changes have never been shown to be associated with cigarette smoking. Evidence for the effect of smoking on the myocardium has been based on qualitative morphologic studies.

One section of myocardium and kidney from 25 smokers and 15 non-smokers was examined and each artery less than 600μ was photographed. Planimetric technique was used to calculate the ratio of intimal to whole vessel wall area. The average value per section was calculated as was the value for each arteriolar size class (greater or less than 150μ).

Smokers have greater intimal thickening than non-smokers in both myocardium and kidney ($P<0.001$). This was true for all vessel sizes examined. Some age-related intimal thickening could be inferred but further investigation is necessary. All statistically insignificant results were analyzed by Type II error analysis to avoid inappropriate acceptance of the null hypothesis.

This is the first study to show a smoking-related increase in intimal thickness in the kidney. Past studies implicating smoking as a factor in myocardial intimal proliferation are confirmed by this investigation. Further work needs to be done on age-related changes.

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INTRODUCTION

Cigarette smoking has been implicated as a major risk factor in increasing the mortality from a variety of disease entities (1,2,3). In conjunction with the mounting evidence for the role of smoking in the etiology of several neoplastic disorders, several anatomical studies have focused on the non-neoplastic effects of cigarette smoke (4,5,6,7,8,9). The most frequently observed response is an increase in fibro-elastic intimal proliferation and hyaline thickening in the intima of vessels of smokers. Similar and supposedly idio-pathic or age-related vascular changes have been noted in the renal vessels (10,11,12). Histologically, the alleged age-related phenomena noted in the kidney resemble those changes seen in the vessels of long-time smokers, i.e., hyaline arterio-lar thickening and fibroelastic proliferation. Since none of the anatomical studies which describe age-related changes have taken smoking into account, the arterial effects attributed to aging might reflect the peripheral effects of cigarette smoking.

Renal function has been noted to decline with age in the absence of overt pathological processes. It is estimated that the glomerular filtration rate declines an average one percent per year after age 40 (13). This is reflected in the need to reduce what is considered a normal creatinine clearance

with aging and at least one linear relationship has been proposed as an age-adjusted estimate (14). In addition, the aged kidney's capacity to secrete p-aminohippurate or to handle an acid-base load is compromised (15,16,17).

In conjunction with the functional declines noted with age, there are a number of histological changes which occur. Rosen describes a number of degenerative events in the aging kidney (18). There are striking changes in the tubules with tubular collapse and atrophy as well as widespread fibrosis and hyalinization of glomeruli. Several studies focus on the effects of aging on the renal vasculature.

Atherosclerotic plaques have long been described in the aorta and coronary arteries. Renal arteries reflect these changes to some extent and arteries down to the size of the arcuate vessels show atherosclerotic changes consisting of fibrous thickening of the intima with reduction in the luminal area. However, intimal lipid as seen in classic lesions in the aorta are not present. Smaller arteries, such as the interlobular arteries, show fibroelastic thickening with reduplication of the internal elastic lamina. The smallest arteries and the arterioles develop hyaline thickening of the intimal and subintimal structures with marked luminal narrowing. Both diabetes mellitus and systemic hypertension can accelerate the severity and frequency of all of these lesions, but the progression of the lesions in all three sizes of arteries can be shown to be a function of aging in normotensive, non-diabetics (10).

Moritz et al. (11) and Bell (12) have described similar lesions in non-hypertensive patients and shown a correlation with age. Intimal thickening of the arterioles was never seen except in conjunction with fibroelastic changes in the small arteries and as such was taken as evidence that arteriolar lesions reflected systemic vascular disease.

These vascular changes are reflected in dynamic studies which attempt to chart renal blood flow in the aging kidney. Cortical arteriolosclerosis was described with a subsequent shift in blood flow to the juxtamedullary glomeruli and medullary vessels (19). In addition studies utilizing radioisotope scans to chart perfusion distribution show focal areas of diminished uptake in elderly patients with no evidence of renal disease. It is suggested that in these elderly patients, focal vascular insufficiency might account for the findings (20).

Cigarette smoking has been identified as a risk factor in cardiovascular disease (1,2,3,21) and most conclusively in coronary artery disease (22,23). This fact led several groups to attempt to define the histological correlates of the observed epidemiological phenomena. Auerbach et al. were among the first to look at small vessel changes in smokers.

All three studies by Auerbach (4,6,7) had essentially the same experimental technique. Autopsy material from various organs were stained with hematoxylin and eosin and elastica van Gieson stains. One observer scored the slides for the

grade of thickening of the vascular walls without prior knowledge of the smoking history. Results were expressed as the percentage of subjects in each age category with moderate to advanced lesions. Auerbach found that for heart, lung, esophagus, adrenal and pancreas, the percentage of subjects with advanced fibrosis or hyaline thickening was greater among smokers. No kidney sections were examined in these studies.

The studies rely exclusively on the qualitative observations of a single observer. Also, the data does not lend itself to statistical analysis making it difficult to judge its significance or reproducibility. However, the results are suggestive of intimal involvement as a function of cigarette smoking.

The other major study in this area focused mainly on the arteriolar medial area. Naeye (8) used the point counting method of Chalkley (24) to measure the medial area as a ratio of media to the average area of the intimal nuclei per arteriole. The latter measurement was used as an internal standard to correct for dilatation and sectioning artifact.

Naeye proposed that the decrease in medial area from sub-epicardial to sub-endocardial arteries was based on a decreasing perfusion pressure gradient. This gradient was felt to be a consequence of sub-epicardial intimal proliferative lesions, which decreased downstream perfusion. Percentage decreases in medial area were statistically greater in smokers.

While the data does suggest an effect of cigarette smoking, the proposed explanation for the phenomenon observed is still a matter of speculation. Naeye fails to examine the intima in detail except to note that sub-endocardial intimal lesions appeared in his youngest subjects and seemed to spread toward the epicardium with age. This fact taken together with his data suggests that, in fact, the actual lesion is not that of medial "atrophy" but rather damage and replacement by the intimal proliferative lesions.

The question of peripheral vascular damage as a significant consequence of cigarette smoking remains enigmatic. The attempt by Naeye to measure medial area represents the first attempt at utilizing reproducible techniques for measuring vascular wall components. However, past studies have implicated the intima as the target of cigarette smoke's vascular effects (5,25). As such, Naeye's paper did not directly address this issue.

This study will attempt to define the degree of intimal damage which may be associated with a history of cigarette smoking in autopsied subjects. Specifically, it will address the issue of renal microvascular changes as a function of smoking history and try to distinguish these effects from "aging" phenomena. Planimetric techniques will be applied to both renal and myocardial small arteries and arterioles in an attempt to develop reproducible and statistically analyzable data.

MATERIALS AND METHODS

Patient Sample

Subjects for this study were selected from two groups of autopsied patients. The first, consisted of all patients autopsied at the West Haven Veteran's Administration Hospital between March and November, 1978. There were, initially, 50 patients available from this group. To augment the population of non-smokers available for analysis, the records of Yale-New Haven Hospital were examined for all non-smokers autopsied between January and December 1978. Fifty-two names were submitted for screening.

Reasons for exclusion from the study included: lack of sufficient available medical history or inadequate smoking history, documented hypertension or repeated blood pressures of 160/90 or greater. Documented diabetes mellitus or repeatedly elevated serum glucose levels of 160 mg% or greater, collagen-vascular disorders, angiitides, gout, chronic aspirin ingestion, chronic pyelonephritis, chronic renal failure, severe and symptomatic obstructive uropathy and acute renal failure from any cause other than acute tubular necrosis were all reasons for exclusion from this study. (See Table 1 for summary.)

Of the 50 subjects available from the Veteran's Hospital, 31 were not excluded. This group consists of 21

smokers, 4 ex-smokers and 6 non-smokers. Ages ranged from 31 to 90 years old. Of the patients screened at Yale-New Haven, 9 patients were included in the study including 4 males and 5 females. Ages ranged from 26 to 83 years.

Section Analysis

Sections were obtained as follows: One section from the left ventricular free-wall was taken from each subject. Care was taken to obtain transmural sections in all cases. Renal slides were obtained from standard autopsy sections and included both cortex and medulla. All sections were stained with elastica van Gieson stain. This technique emphasizes both internal and external elastic lamina allowing for easier recognition of wall structures.

Each slide was assigned a random number using a standard random number table. All measurements were carried out on the slides without knowledge of the autopsy number or smoking history. One myocardial and one renal section was examined for each patient.

Planimetric analysis was used to measure the degree of intimal proliferation in the arteries. Only vessels cut in cross-section or at a shallow tangential angle were analyzed. Longitudinally cut arteries or those obviously damaged by preparation techniques were excluded. The number of arteries and arterioles used for analysis per section ranged from 2 to 12. Random sampling of arteries was maintained by analyzing every possible artery in a section. Acceptable arteries ranged in size from approximately 25μ to 550μ (Table 1).

Each artery to be measured was photographed at the highest magnification which would allow inclusion of the whole vessel. The magnification used was noted for each artery photographed in order to compute and compare vessel sizes.

The following measurements were made on each vessel. Using a Kontron MOP/AM01 planimeter, the area of the lumen (L), lumen plus intima (I), and whole vessel (M) were measured. To measure I, the internal elastic lamina was designated the outer limit of the intima. For vessels with fibroelastic proliferation, the outermost elastic lamina not containing medial muscle cells was so designated. In vessels too small to have an external elastic lamina, the outer edge of the medial muscle was considered the outer limit of the artery or arteriole. All area results were recorded in millimeters squared (mm^2) and diameters were first measured in millimeters and then divided by the magnification of the photograph to obtain the true vessel diameter. This method of measuring the diameter cannot account for tissue shrinkage secondary to fixation nor for severe vessel dilatation. Only two broad categories of arteries, i.e., greater or less than 150μ, will be compared, so that minor changes in diameter due to fixation artifact will not change the conclusions.

The tangentiality of the plane of section to the vessels changes their apparent size. The narrowest diameter was measured, since it most closely approximates the true diameter of the vessel. No corrective measures are needed

for vessel wall components since all comparisons are in terms of ratios of the wall components. These ratios are unaffected by the tangentiality because each component has its area changed by the same factor.

In order to derive the percentage contribution of the intima to the total wall area, the lumen area (L) was subtracted from the composite areas I and M.

Therefore, the area of the intima is the area of the intima plus lumen (I) minus the lumen area (L):

Intimal area = I-L

The area of the vascular wall is calculated from the whole vessel area (M) minus the lumen area (L):

Vessel wall area = M-L

The ratio, therefore, of the intima to the vessel wall or the relative contribution of the intima is:

% Intima (%int.) = I-L/M-L

This value is independent of the magnification of the photograph since the units (mm^2) cancel out. Interartery comparisons can be carried out using % int. values without further correction. Therefore, this value was derived for every vessel photographed and recorded for analysis.

Statistical Analysis

Subjects were categorized by age and smoking habit. Four major groups resulted. Smokers were divided into an

older group with ages ranging from 60-90 and a younger group less than 60 years old. Non-smokers were divided in a similar fashion. Two tissue types, myocardium and kidney, were evaluated in every group.

The average value for % intima (AVG.) was calculated and recorded for each tissue type in every patient. Since a majority of sections (79%) had vessels both greater and less than 150μ in diameter, the average % intimal value for small vessel (less than 150μ) and larger vessels (150μ or greater) were also calculated for each section analyzed.

Means and variances for each size artery (AVG., $<150\mu$, and $>150\mu$) in myocardium and kidney were calculated for each of the four major groups mentioned above (Table 2). A Bartlett's test of homogeneity of variance showed no significant difference in the intergroup variance. Therefore, the student t-test was utilized to compare mean values. The following comparisons were made:

Comparison 1: Smokers versus Non-smokers (Tables 3-12)

A. All smokers v. all non-smokers--For each tissue type, each arterial size class in smokers was compared to its counterpart in the non-smoking population. Smoker means were compared both with and without the values for the four (4) ex-smokers.

B. Smokers $\geq$ 60 y.o. versus non-smokers $\geq$ 60 y.o.--For each tissue type (myocardium and kidney), each arterial size class in smokers $\geq$60 were compared to the same size class in non-smokers $\geq$ 60. Smoker %

intima means were calculated and compared both with and without the values for the four ex-smokers.

C. Smokers < 60 y.o. versus non-smokers < 60 y.o.--For each tissue type, each arterial size class in smokers < 60 y.o. were compared to the same size class in non-smokers < 60 y.o. There were no ex-smokers in this latter group.

D. Cross-correlations--Similar calculations were made using the following groups: Smokers ≥ 60 y.o. versus non-smokers < 60 y.o. were compared by tissue type and arterial size class; smokers < 60 y.o. versus non-smokers ≥ 60 y.o. were similarly compared.

Comparison 2: Small Vessel (<150μ) versus Large Vessel (>150μ) (Tables 13-16)

A. Smokers--This group was broken down into ages ≥60 y.o. and < 60 y.o. Within each tissue type, small vessels were compared to large vessels by comparing the mean for each size class. For the group ≥ 60 y.o., values were compared both with and without the ex-smokers.

B. Non-smokers--The same calculations were carried out on this group as in 3A.

For all calculations, P values of 0.05 or less were considered significant. For all values of P > 0.05, Type II error analysis was calculated to avoid an inappropriate acceptance of the null hypothesis. The value of β is the probability of accepting the null hypothesis when it is, in fact, false (43). Unlike the calculation of the standard P

value, β is based on a non-zero difference between means (D). The choice of D is empirical and usually based on past investigations or observations. For the purposes of this study, no such past observations exist and values for D were chosen from minimum significant differences of 0.07 to a maximum of 0.15.

Finally, linear regression analyses were calculated in an attempt to establish a relationship between % int. values and 1) smoking history as either packs per day or pack-years and 2) age.

TABLE 1

EXCLUSION CRITERIA

Patients -
1) Lack of sufficient medical history
2) Lack of or inadequate smoking history
3) Documented diastolic hypertension
4) Repeated blood pressures of 160/90 or greater
5) Documented diabetes mellitus
6) Repeatedly elevated serum glucose of 160 mg% or elevated fasting blood sugar
7) Collagen-vascular disorders
8) Angiitides, e.g., Buerger's disease
9) Gout
10) Chronic aspirin ingestion
11) Chronic pyelonephritis
12) Chronic renal failure
13) Severe and symptomatic obstructive uropathy
14) Acute renal failure--from any cause other than acute tubular necrosis

Arteries -
1) Vessels cut in a longitudinal plane
2) Vessels damaged by preparation techniques
3) Vessels greater than approximately 600μ.
4) All epicardial vessels

RESULTS

The raw data is listed in Appendix I. Table 2 contains the % intima values for each patient with the mean, standard deviation and variance for each subgroup. Tables 3-20 detail the results of the various comparisons. Calculations were done both with and without the four ex-smokers in this study. Since removal of these four subjects did not alter the significance of the data, they were included in all reported results.

Smokers versus Non-smokers

Myocardium

A comparison of all smokers against all non-smokers, regardless of age, reveals a highly significant increase in the % intima in smokers (0.50 ± 0.07-AVG.) over non-smokers (0.31 ± 0.08-AVG.) with $P < 0.001$ (Table 3). For each arterial size class, the relative contribution of the intima to the whole vessel area is similarly significantly increased in smokers ($P < 0.05$ to $P < 0.001$).

For smokers older than 60, comparison to age-matched controls yields the same relationship. Smokers (0.41 ± 0.06-AVG.) show an increase in % intima over non-smokers (0.33 ± 0.08-AVG.) which is highly significant ($P < 0.02$), (Table 5).

For smokers under age 60, comparison to age-matched

controls yields similar relationships (Table 7). The increase in % intimal area in smokers is significant for the average (smokers-0.38±0.09; non-smokers-0.29±0.07; $P < 0.05$) % int. and for arterioles <150µ (smokers 0.41±0.10; non-smokers-0.29±0.08; $P < 0.02$). Vessels >150µ show an insignificant difference ($P < 0.30$). However, β analysis indicates that a significant difference cannot be ruled out. A larger N would clarify this uncertainty.

Comparison of smokers ≥60 years old (0.41±0.06-AVG.) versus non-smokers < 60 (0.29±0.07-AUG.) shows a highly significant increase ($P < 0.001$). This relationship holds for all vessel sizes examined (Table 9).

Comparison of smokers < 60 y.o. (0.38±0.09-AVG.) versus non-smokers > 60 (0.33±0.08-AVG.) shows some statistical uncertainty ($P < 0.30$, $\beta > 0.10$). A significant difference cannot be ruled out in AVG. or the <150µ groups. However, a comparison of the vessels >150µ for these age groups show younger smokers (0.31±0.07) have a significantly greater % intima than older non-smokers (0.21±0.02) at $P < 0.05$ (Table 11).

Kidney

A comparison of all smokers against all non-smokers, regardless of age, reveals a highly significant increase in the % intima in smokers (0.46±0.07-AVG.) over non-smokers (0.34±0.09-AVG.) with $P < 0.001$ (Table 4). For each arterial size class, the relative contribution of the intima to the whole vessel are is similarly significantly increased in smokers ($P < 0.001$).

For smokers older than 60, comparison to age-matched controls yields the same relationship. Smokers (0.47 ± 0.05-AVG.) show an increase in % intima over non-smokers (0.37 ± 0.07-AVG.) which is significant ($P < 0.01$), (Table 6). Similar calculations on vessels $< 150\mu$ are significant ($P < 0.05$). Again, vessels $> 150\mu$ in diameter had % intima difference which was insignificant ($P < 0.10$). β analysis of this data indicates that a significant difference can not be ruled out. A larger N would clarify this uncertainty.

For smokers under age 60, comparison to age-matched controls yields similar relationships (Table 8). Smokers (0.44 ± 0.10-AVG.) show an increase in % intima over non-smokers (0.32 ± 0.10) which is significant ($P < 0.02$). This relationship also exists for vessels $< 150\mu$ and $> 150\mu$ at $P < 0.02$ and < 0.05, respectively.

Comparison of smokers ≥ 60 y.o. (0.47 ± 0.05-AVG.) versus non-smokers < 60 y.o. (0.32 ± 0.10-AVG.) was highly significant ($P < 0.001$) for all vessels examined (Table 10).

Comparison of younger smokers < 60 y.o. (0.44 ± 0.10-AVG.) with older non-smokers ≥ 60 (0.37 ± 0.07-AVG.) shows the difference to be insignificant ($P < 0.20$). Similar results were obtained when each vessel size class was examined. β analysis indicated that a significant difference could not be ruled out in any of the size classes (Table 12).

Small Vessels versus Large Vessels

Myocardium

For smokers ≥ 60 y.o., comparison of small (0.46 ± 0.08)

versus large vessels (0.31 ± 0.06) indicates that the % intima is statistically greater in small vessels ($P < 0.001$), (Table 13).

For smokers less than 60 years old, small vessels have a greater % intima at $P < 0.05$ (Table 13).

For non-smokers ≥ 60 y.o., comparison of small (0.29 ± 0.04) versus large vessels (0.21 ± 0.02) indicates that the % intima is greater in small vessels ($P < 0.05$), (Table 15). However, for non-smokers less than 60 y.o., there was no significant difference with a $P < 0.40$ and $\beta < 0.10$ (Table 15).

Kidney

For smokers ≥ 60 y.o., large vessels (0.51 ± 0.08) had a greater % intima than small vessels (0.44 ± 0.09) at a $P < 0.05$ (Table 14). Non-smokers, in the same group, show similar results ($P < 0.05$), (Table 16).

For smokers less than 60 y.o., small vessels (0.44 ± 0.12) were compared to large vessels (0.47 ± 0.09), (Table 14) and the difference was not significant ($P < 0.20$). Non-smokers, in the same group, also show no significant difference ($P < 0.20$), (Table 16).

Age Comparison

Myocardium

Comparison of smokers ≥ 60 y.o. (0.41 ± 0.06-AVG.) with smokers < 60 y.o. (0.38 ± 0.09-AVG.) showed no significant difference ($P < 0.50$), (Table 17). Vessels $> 150\mu$ also showed no difference ($P < 0.90$). However, vessels $< 150\mu$ had a possible significant difference by β analysis.

In non-smokers, comparison by age showed more uncertainty and a larger N would be required to define the significance of any difference (Table 19).

Kidney

Comparison of smokers ≥ 60 y.o. (0.47 ± 0.05-AVG.) with smokers < 60 y.o. (0.44 ± 0.10-AVG.) showed no significant difference ($P < 0.30$). Vessels $< 150\mu$ also showed no difference ($P < 0.90$). However, vessels $> 150\mu$ showed more uncertainty ($P < 0.10$) since β analysis indicated that a significant difference could not be ruled out (Table 18).

Non-smokers in the kidney, like the results for myocardium, show greater uncertainty. Comparison of older subjects (0.37 ± 0.07-AVG.) versus younger ones (0.32 ± 0.10-AVG.) are not, strictly defined, significant ($P < 0.20$). Vessels $< 150\mu$ and $> 150\mu$ also showed P values > 0.05. β analysis of all three groups indicates that a significant difference can not be ruled out (Table 20).

Linear Regression Analysis

Percent intima values in each vessel size class were compared against 1) smoking history both as packs per day and as pack-years, and 2) ages of subjects. No significant relationships could be established among the multiple categories examined by this method.

TABLE 2

Group	Subject	Age	Smoking History	Myocardium - % int.			Kidney - % int.		
Smokers			(ppd x years)	AVG	<150µ	>150µ	AVG	<150µ	>150µ
60 and >	1	90	1-2 x 60	0.43	0.43	--	0.52	0.41	0.60
	2	79	1 x 40(15y)	0.44	0.44	--	0.48	--	0.48
	3	70	1 x 50	0.36	0.40	0.31	0.41	0.31	0.45
	4	70	2-5 x 50(5y)	0.59	0.66	0.33	0.42	0.38	0.43
	5	69	1-1.5 x 40	0.38	0.43	0.29	0.55	0.61	0.54
	6	68	1 x 50	0.46	0.46	--	0.46	0.55	0.41
	7	68	2 x 50	0.45	0.45	0.45	0.54	0.32	0.63
	8	67	1.5-2 x 40	0.40	0.40	--	0.50	0.43	0.53
	9	66	3-4 x 40(8y)	0.36	0.37	0.29	0.48	0.37	0.53
	10	64	2 x 30	0.41	0.45	0.30	0.42	0.38	0.51
	11	61	1.5 x 30(10y)	0.39	0.46	0.32	0.51	0.51	0.52
	12	61	1.5-2 x 30	0.39	0.41	0.27	0.51	0.56	0.46
	13	61	1.5 x 40	0.40	0.45	0.25	0.50	0.48	0.55
	14	61	2 x 40	0.42	0.47	0.25	0.36	0.37	0.35
	15	60	1 x 40	0.31	0.31	--	0.45	0.41	0.56
MEAN (ALL) ± S.D.				0.41±0.06	0.44±0.07	0.31±0.06	0.47±0.05	0.44±0.08	0.50±0.07
Without ex-smokers				0.40±0.04	0.42±0.04	0.30±0.07	0.45±0.06	0.44±0.10	0.51±0.08
Variance - all				0.00	0.01	0.00	0.00	0.01	0.01
Variance - without ex-smokers				0.00	0.00	0.00	0.00	0.01	0.01
( ) - years since last smoked									
Smokers < 60	16	59	1.5-2 x 40	0.34	0.34	0.24	0.62	0.57	0.64
	17	58	3 x 40	0.39	0.39	0.37	0.34	0.30	0.44
	18	57	1.5 x 37	0.36	0.35	0.38	0.39	0.36	0.52
	19	57	1.5-2 x 40	0.30	0.39	0.24	0.50	0.54	0.46
	20	57	2-2.5 x 40	0.50	0.59	0.32	0.44	0.50	0.38
	21	57	2-3 x 40	0.22	0.22	--	0.41	--	0.41
	22	56	4 x 30	0.43	0.43	--	0.54	0.54	0.54
	23	53	1 x 25	0.34	0.38	0.25	0.51	0.53	0.50
	24	49	2 x 30	0.50	0.53	0.40	0.32	0.29	0.34
	25	37	1.5 x 20	0.45	0.45	--	0.35	0.29	0.42

Group	Subject	Age	Smoking History	Myocardium - % int.			Kidney - % int.		
			(ppd x years)	AVG	<150μ	>150μ	AVG	<150μ	>150μ
MEAN (ALL) ± S.D.				0.38±0.09	0.41±0.10	0.31±0.07	0.44±0.10	0.44±0.12	0.47±0.09
Variance				0.01	0.01	0.00	0.01	0.01	0.01
SMOKER MEAN (Combined ages) ± S.D.				0.40±0.07	0.43±0.09	0.31±0.06	0.46±0.07	0.44±0.10	0.49±0.08
SMOKER MEAN without ex-smokers				0.39±0.07	0.42±0.08	0.31±0.07	0.46±0.09	0.44±0.11	0.49±0.09
Non-Smokers									
> 60 y.o.	26	83		0.35	0.35	--	0.48	0.36	0.61
	27	83		0.29	0.32	0.22	0.32	0.29	0.46
	28	80		0.42	0.42	--	0.43	0.47	0.38
	29	75		0.24	0.25	0.23	0.32	0.29	0.38
	30	62		0.26	0.30	0.19	0.37	0.29	0.47
	31	60		0.42	0.42	--	0.32	0.33	0.30
MEAN ± S.D.				0.35±0.11	0.34±0.07	0.21±0.02	0.37±0.07	0.34±0.07	0.43±0.11
Variance				0.01	0.00	0.00	0.00	0.00	0.01
Non-Smokers									
> 60 y.o.	32	56		0.30	0.31	0.26	0.46	0.46	0.45
	33	52		0.45	0.45	--	0.51	0.31	0.57
	34	52		0.29	0.25	0.39	0.30	0.29	0.37
	35	51		0.22	0.22	0.21	0.21	0.15	0.26
	36	44		0.21	0.22	0.14	0.25	0.31	0.17
	37	34		0.26	0.26	--	0.27	0.26	0.36
	38	32		0.36	0.36	--	0.28	0.28	0.27
	39	31		0.31	0.33	0.28	0.36	0.36	0.40
	40	26		0.25	0.25	--	0.26	0.25	0.29
MEAN ± S.D.				0.29±0.07	0.29±0.08	0.26±0.09	0.32±0.10	0.30±0.08	0.35±0.12
Variance				0.01	0.01	0.01	0.01	0.01	0.01
NON-SMOKER MEAN (Combined ages) ± S.D.				0.31±0.08	0.31±0.07	0.24±0.07	0.34±0.09	0.31±0.08	0.38±0.12

TABLES 3-20

1) All % intima values are followed by a standard deviation.
2) ( ) - number of subjects in each category.
3) * - Significant difference cannot be ruled out by β analysis.

TABLE 3

All Smokers v. All Non-smokers
Myocardium

Vessels	AVG.	<150	>150
Smokers:	0.40±0.07 (25)	0.43±0.09 (25)	0.31±0.06 (17)
Non-smokers:	0.31±0.08 (15)	0.31±0.08 (15)	0.24±0.07 (8)
P < :	0.001	0.001	0.05

TABLE 4

All Smokers v. All Non-smokers
Kidney

Vessels	AVG.	<150	>150
Smokers:	0.46±0.07 (25)	0.44±0.10 (23)	0.49±0.08 (25)
Non-smokers:	0.34±0.09 (15)	0.31±0.08 (15)	0.38±0.12 (15)
P < :	0.001	0.001	0.001

TABLE 5

Smokers ≥ 60 versus Non-smokers ≥ 60
Myocardium

Vessels	AVG.	<150	>150
Smokers:	0.41±0.06 (15)	0.44±0.07 (15)	0.31±0.06 (10)
Non-smokers:	0.33±0.08 (6)	0.34±0.07 (6)	0.21±0.02 (3)
P < :	0.02	0.02	0.05

TABLE 6

Smokers ≥ 60 versus Non-smokers ≥ 60
Kidney

Vessels	AVG.	<150	>150
Smokers:	0.47±0.05 (15)	0.44±0.09 (14)	0.50±0.07 (15)
Non-smokers:	0.37±0.07 (6)	0.34±0.07 (6)	0.43±0.11 (6)
P <:	0.01	0.05	0.10*

TABLE 7

Smokers < 60 versus Non-smokers < 60
Myocardium

Vessels	AVG.	<150	>150
Smokers:	0.38±0.09 (10)	0.41±0.10 (10)	0.31±0.07 (7)
Non-smokers:	0.29±0.07 (9)	0.29±0.08 (9)	0.26±0.09 (5)
P <:	0.05	0.02	0.30*

TABLE 8

Smokers < 60 versus Non-smokers < 60
Kidney

Vessels	AVG.	<150	>150
Smokers:	0.44±0.10 (10)	0.44±0.12 (9)	0.47±0.09 (10)
Non-smokers:	0.32±0.10 (9)	0.30±0.08 (9)	0.35±0.12 (9)
P <:	0.02	0.02	0.05

TABLE 9

Smokers > 60 versus Non-smokers < 60
Myocardium

Vessels	AVG.	<150	>150
Smokers:	0.41±0.06 (16)	0.44±0.07 (15)	0.31±0.06 (10)
Non-smokers:	0.29±0.07 (9)	0.29±0.08 (9)	0.26±0.09 (5)
P <:	0.001	0.001	0.30*

TABLE 10

Smokers > 60 versus Non-smokers < 60
Kidney

Vessels	AVG.	<150	>150
Smokers:	0.47±0.05 (15)	0.44±0.09 (14)	0.50±0.07 (15)
Non-smokers:	0.32±0.10 (9)	0.30±0.08 (9)	0.35±0.12 (9)
P <:	0.001	0.01	0.001

TABLE 11

Smokers < 60 versus Non-smokers ≥ 60
Myocardium

Vessels	AVG.	<150	>150
Smokers:	0.38±0.09 (10)	0.41±0.10 (10)	0.31±0.07 (7)
Non-smokers:	0.33±0.08 (6)	0.34±0.07 (6)	0.21±0.02 (3)
P <:	0.30*	0.20*	0.05

TABLE 12

Smokers < 60 versus Non-smokers ≥ 60
Kidney

Vessels	AVG.	<150	>150
Smokers:	0.44±0.10 (10)	0.44±0.12 (9)	0.47±0.09 (10)
Non-smokers:	0.37±0.07 (6)	0.34±0.07 (6)	0.43±0.11 (6)
P < :	0.20*	0.20*	0.90*

TABLE 13

Small Vessels versus Large Vessels
Smokers--Myocardium

Vessel	Age	≥60	<60
<150		0.46±0.08 (15)	0.42±0.10 (10)
>150		0.31±0.06 (10)	0.31±0.07 (7)
P < :		0.001	0.05

TABLE 14

Small Vessels versus Large Vessels
Smokers--Kidney

Vessel	Age	≥60	<60
<150		0.44±0.09 (14)	0.44±0.12 (9)
>150		0.51±0.08 (15)	0.47±0.09 (10)
P < :		0.05	0.20

TABLE 15

Small Vessels versus Large Vessels
Non-smokers--Myocardium

Vessel	Age	≥60	<60
<150		0.29±0.04 (6)	0.27±0.05 (9)
>150		0.21±0.02 (3)	0.26±0.09 (5)
P < :		0.05	0.40

TABLE 16

Small Vessels versus Large Vessels
Non-smokers--Kidney

Vessel	Age	≥60	<60
<150		0.34±0.07 (6)	0.30±0.08 (9)
>150		0.43±0.11 (6)	0.35±0.12 (9)
P < :		0.05	0.20

TABLE 17

Age Comparison
Smokers--Myocardium

Age	Vessel	AVG.	<150	>150
≥60		0.41±0.06 (15)	0.44±0.07 (15)	0.31±0.06 (10)
<60		0.38±0.09 (10)	0.41±0.10 (10)	0.31±0.07 (7)
P < :		0.50	0.50*	0.90

TABLE 18

Age Comparison
Smokers--Kidney

Age	Vessel	AVG.	<150	>150
≥60		0.47±0.05 (15)	0.44±0.09 (14)	0.50±0.07 (15)
<60		0.44±0.10 (10)	0.44±0.12 (9)	0.47±0.09 (10)
P <:		0.30	0.90	0.10*

TABLE 19

Age Comparison
Non-smokers--Myocardium

Age	Vessel	AVG.	<150	>150
≥60		0.33±0.08 (6)	0.34±0.07 (6)	0.21±0.02 (3)
<60		0.29±0.07 (9)	0.29±0.08 (9)	0.26±0.09 (5)
P <:		0.50*	0.30*	0.25

TABLE 20

Age Comparison
Non-smokers--Kidney

Age	Vessel	AVG.	<150	>150
≥60		0.37±0.07 (6)	0.34±0.07 (6)	0.43±0.11 (6)
<60		0.32±0.10 (9)	0.30±0.08 (9)	0.35±0.12 (9)
P <:		0.20*	0.20*	0.10*

DISCUSSION

Cigarette use, and tobacco use in general, have long been the subject of serious and often heated debate. Since the 16th century when it was first introduced to Western man, tobacco has been extolled as medicinal and vilified as being, at best, a loathsome custom (21). Despite the condemnation leveled against its use, the amount and frequency of tobacco usage has increased steadily.

Until the early 1900's, the major forms of tobacco consumption consisted of pipe and cigar smoking, and chewing tobacco. In the year 1900, of the total of 7.43 pounds of tobacco used per person, a full 4.1 pounds were consumed as chewing tobacco and 1.6 pounds as pipe tobacco (26). In that year the per capita cigarette consumption was a meager 49. This relationship changed rapidly over the ensuing decades. While tobacco use in general increased and reached a level of approximately 11 pounds per person per year by 1960, the amount of pipe tobacco, cigars and chewing tobacco used decreased by at least 50% in that time. The decrease in these products was offset by a dramatic increase in cigarette use. From an average 49 cigarettes per capita in 1900, the consumption of cigarettes rose to almost 4,000 cigarettes for every adult American over the age of 15 years by 1960 (26).

In the early 1900's, statisticians first noted disturbing trends among tobacco users. There were indications that this group suffered from such diverse disease entities as lung cancer, cardiac and non-cardiac vascular disorders and non-neoplastic respiratory disease more often than their non-smoking counterparts (21). This data, like the many retrospective studies which followed, was often criticised on several points. As in any retrospective study, especially one using mortality as an endpoint, inaccurate data from secondary sources and selection bias are difficult to avoid. The compilation of retrospective data necessitates assumptions about the relationship between the investigated topic and the suspected causative factors. As such, the data may also suggest that smoking may only represent a marker of some other quality or habit which would predispose to one or more of the above diseases.

In the early 1950's, Doll and Hill published the first prospective analysis of the risk of lung cancer and other diseases as a function of smoking habit (1). This study was able to statistically link cigarette smoking among British doctors with their deaths from lung cancer and "coronary thrombosis." These two entities showed the strongest correlation, but non-neoplastic respiratory diseases also showed some linkage with smoking history. In addition, they were able to demonstrate a gradation of mortality ratios based on the extent of tobacco use.

Hammond and Horn reported, in a 44-month follow-up

study of 188,000 men, that mortality rates were higher in smokers. Of 11,870 men who died in this time, 4,406 occurred among men with a history of regular cigarette smoking only. Only 2,623 of these men would have died had their age-specific death rates been the same as for non-smokers in this population. The mortality ratio is then 1.7. These statistics were also broken down by disease category. For lung cancer, the mortality ratio for smokers was 10.73 and for all heart and circulatory diseases 1.57. Coronary artery disease was the cause of death 1.7 times as often in smokers. Hypertension was not associated with an increased mortality in smokers and generalized arteriosclerosis showed only a modest, statistically insignificant rise in smokers. In diseases which showed a correlation with smoking, heavy smokers suffered more often than light or occasional smokers (2).

Subsequently other reports demonstrated a correlation between cigarette smoking and mortality rates. In all, seven studies showed, in a prospective fashion, the serious epidemiological outcome of cigarette use and formed the basis of the arguments presented in the 1964 report to the Surgeon General of the U.S. Public Health Service (21). A recent update of the Surgeon General's report reconfirms these findings and extends the results, previously lacking evidence, to women (27). Finally, a recent article by Friedman et al. (28) assessed the relation of cigarette smoking to mortality in an 11-year follow-up study of 4,004 men and women.

Multivariate analysis showed a consistent correlation between smoking and mortality from all causes and most strikingly with coronary artery disease.

Other studies solidified the association between cigarette use and deaths due to cardiovascular disease. The most striking association remained the relationship between smoking and myocardial infarction (22,29,30,31,32,33). This link was of higher reliability than for angina pectoris which was either weakly linked (34,35) or not linked at all (23).

Auerbach et al. became interested in the pathological effects which might relate to cigarette use and the changes associated with constant exposure to smoke. The preliminary report by his group in 1957 (36) indicated that the frequency of carcinoma _in situ_, squamous metaplasia, stratification and basal cell hyperplasia was increased in smokers. The full study (37) consisted of 402 white males with reliable smoking histories. From each subject, 55 areas of the tracheobronchial tree were examined microscopically without prior knowledge of the smoking history. The most striking lesion observed, other than invasive carcinoma, was areas showing increased numbers of atypical cells with absent cilia. This lesion was never found in non-smokers, but was present in 4.3% of sections from smokers of 1-2 packs per day; 11.4% of sections from those smoking 2 or more packs per day and in 15% of these sections obtained from patients succumbing to lung cancer.

The demonstration of specific pathological changes, which were statistically linked to the amount and frequency of cigarette use, was the basis of efforts to elucidate other local changes in the lung. One such study linked vascular changes in the lungs of rats exposed to cigarette smoke (38). This led Auerbach et al. to consider the effects smoking might have on the lung parenchyma and vasculature in humans. A study was undertaken between 1955 and 1960 on 1582 autopsied males (39). Histologic slides were scored blindly and in random number order. The following pathological changes were rated by one observer using a scaled grading system of 0 to 3 or 4. Zero was normal and ratings of 3-4 indicated advanced changes. Four areas of each slide were averaged and in a preliminary study of 242 subjects, the agreement between first and second readings was 0.90. Pathological changes observed were rupture of alveolar septa, fibrosis, thickening or attachments to the septa and thickening of the walls of arteries and arterioles.

The results indicated several interesting items. First, there was no significant difference, for any of the changes, between smokers by race when matched for age and smoking history. All changes were closely allied to age and cigarette smoking. Among men of the same age, non-smokers showed far less changes than light smokers. Light smokers (1 pack per day) showed far less change than heavy smokers (2 packs per day or greater). Ex-smokers who had not smoked for at least three years prior to death showed less change

than equivalent smokers who had continued smoking up to the time of their terminal event. Strikingly, non-smokers over age seventy had far less pulmonary parenchymal and vascular injury than smokers less than forty-five years old.

Two alternate theories were proposed to explain the tissue response to cigarette smoke seen in the lung. The first is that these effects are simply a result of irritant factors in the smoke acting locally on the lung parenchyma. The other possible explanation is that the pathological changes noted are the pulmonary manifestations of a more generalized systemic effect of some ingredient in the inhaled smoke. This latter theory was enticing in the face of all the epidemiological data linking smoking to disease in a variety of organ systems.

The first of two studies designed to elucidate the systemic effects was published in 1968 (4). Again, looking at small artery and arteriolar changes as a marker of the effect of smoking on tissue, five types of tissue were examined for "fibrous thickening" of the small arteries and arterioles. Thickening was measured on a qualitative grading scheme of 0-3 for arterioles and 0-2 for small arteries and all sections were examined by one observer. As in the other studies, slides were scored without knowledge of the smoking history and in random order. Tissues examined included trachea and main-stem bronchi, esophagus, stomach wall, pancreas, and adrenal gland. Of these, the latter two have no chance of having had direct contact with cigarette smoke and could

only have been affected by substances carried via a hematogenous route. No samples from kidney were examined.

The results were expressed as "more than a slight degree," i.e., greater than grade 1 degree, of fibrous thickening as determined by the average reading per patient. The findings, standardized for age, indicated that the percentage of subjects with abnormal readings increased with the amount of cigarettes consumed per day. This was true for all tissues examined. There was, however, no attempt to correlate individual smoking history with the extent of thickening of vessels in that subject.

During this time, it was shown that various toxins can affect the myocardial vasculature. One study (25) reported that denicotinized tobacco proteins given to rabbits apparently caused a thickening of the walls of the small arteries in the myocardium. This was felt to be on an "allergic" basis. Another mechanism for the systemic effects of cigarette smoking invoked the presence of high concentrations of carbon monoxide in smoke. Wanstrup et al. (5) exposed rabbits to modest levels of carbon monoxide for three months and then examined aortas for signs of damage. In those rabbits exposed to carbon monoxide, there were focal degenerative and "reparative" intimal changes which were present in a significantly higher percentage than in controls. These findings were felt to strengthen the case for a systemic effect of tobacco smoke.

The extent to which the myocardial vasculature in humans reflect these supposed systemic effects was addressed

by a study published in 1970. Auerbach et al. studied both beagle dogs, trained to smoke, and human smokers with post-mortem examinations (6). In the human study, 746 men with known smoking histories were examined. Three slides were taken from each subject, one each from right ventricle, interventricular septum and the left ventricular free wall. As before, the randomized slides were qualitatively graded by one observer. All arterioles in a section were examined and a slide was assigned a grade on the basis of the thickest arteriole seen. The extent of agreement between areas of the myocardium within a given subject seemed to rule out a local effect as a cause of arteriolar thickening.

The grade or degree of thickness rose with advancing age when the subjects were standardized by smoking history. This agreed with past studies on other organs. By age group, the degree of wall thickness was greater among smokers over their non-smoking counterparts. Again, in the smoking group, the grade of arteriolar thickening showed an increase with the amount of cigarettes consumed. Here, as in the past, criticism rests on two points. First, the data is not subjected to statistical analysis for the validity of the trends cited. In addition, the use of only one observer assigning qualitative grading values fails to address the issue of reproducibility.

The two studies on beagle dogs taught to smoke showed results similar to past studies on human subjects. Two additional pieces of information emerged from the data. First,

there was a difference in arteriolar thickening based on whether the dogs smoked filtered or non-filtered cigarettes, with non-filtered cigarettes causing greater damage. Since filters do not affect the carbon monoxide level in smoke (21), this data argued against Wanstrup's thesis that carbon monoxide was the major cause of vascular damage. The second finding related duration of smoking to an increase in apparent vascular damage. The studies on dogs suffer from the same shortcomings as the human portion of this study and the data must be assessed with that in mind.

Further investigation by Auerbach led to the most recent paper in 1976 (7) which used his previous technique to look at both large and small vessel disease as a function of smoking history. Since several studies had shown the relationship of coronary and aortic atherosclerosis with cigarette smoking (40,41), this present study was constructed to examine the coronary arterial system on both macro- and microscopic levels.

The macroscopic and microscopic coronary artery findings in this study were similar to previous findings of increased coronary atherosclerosis and fibrous intimal thickening in smokers. In fact, fibrous thickening was absent in 60.6% of men under 65 who had never smoked regularly. However, in the same age group, fibrous intimal thickening was absent in less than one percent of those smoking one pack per day or more.

As in the coronary artery portion, the intramyocardial arteries and arterioles were examined for fibrous intimal

thickening. In addition, arterioles were examined for hyaline thickening of the intima following observations of similar lesions in beagle dogs tracheostomized and trained to smoke cigarettes. An attempt was made to exclude disease entities either associated with known vascular sequelae or likely to introduce bias into the study and, therefore, subjects with diabetes mellitus, fatal coronary artery disease and those with heart weights greater than 500 gm. were excluded.

Findings in this 1976 study confirmed past studies to the extent that moderate to advanced thickening was present in 60-70% of smokers using greater than one pack per day. In those who never smoked regularly, the same changes were noted in only 0 to 0.4% of subjects. Strikingly, hyaline arteriolar thickening was noted in 97-98% of those smoking greater than one pack per day. No subject was noted to have such arteriolar lesions if they had never smoked regularly. While this data is extremely suggestive, no statistical analysis was done to attest to its validity.

Since the publication of the above study, two additional studies have been reported which, in part, address some of the reservations mentioned above. Specifically, both studies attempt to measure proliferative lesions or their consequences by some objective means.

The first of these, by Naeye et al. (8), introduces several new aspects to this area of investigation. This study attempts to show that proliferative lesions in sub-epicardial vessels, because they decrease perfusion pressure distally, actually cause a decrease or "atrophy" in arteriolar muscle

mass in the sub-endocardial vessels. The proposed mechanism is based on studies which show that arteriolar medial muscle mass reflects perfusion pressure. The paper attempts to demonstrate the relationship of sub-endocardial ischemia to sub-epicardial intra-myocardial lesions.

One of the contributions this paper makes to this field of investigation is an attempt to screen subjects for, and exclude them on the basis of, systemic disorders with known vascular sequelae. In addition to diabetes mellitus excluded by Auerbach, hypertension, hypertrophic cardiomyopathy from any cause, transmural infarctions and "collagen disorders" were all reasons for exclusion.

The most important contribution of this work, was the application of microscopic area measurement techniques to analyze the arterioles. The point counting method first described by Chalkley (24) was used to measure the area of arteriolar media and all values were expressed as the area of the media to the average area of intimal nuclei per arteriole. The latter value was used as an internal standard to correct for dilatation and artifacts produced in sectioning. The use of area measurement eliminated the criticism of one-observer bias by using quantitative data.

Naeye examined arteries from 34 non-smokers (13 women and 21 men) and 43 smokers (16 women and 27 men). Consecutive autopsies were used as much as possible. The results purport to show a decrease in arteriolar medial muscle mass from epi- to endocardium which was greater in smokers at P

values of 0.05 or less. However, the statement is made that proliferative intimal lesions appear in the sub-endocardial vessels at the youngest ages examined. With the age of the patient and smoking history these lesions appear to spread toward the epicardium. Thus, it is not clear whether the greater decrease in the media of the sub-endocardial vessels of smokers represents "atrophy" or instead a greater involvement with intimal and sub-intimal lesions. Although the explanation of the data is open to interpretation, the results do show quantitatively valid evidence of greater damage to the arteries of smokers.

Another approach to the problem of measuring the changes described by Auerbach et al. and the only study to include the kidney was that of Seez et al. (9). The arteries examined ranged in size from 300 to 500μ in diameter and were examined by an intraocular scale at constant magnification. The thickness of the area of severest intimal thickening in an artery was measured and expressed as a fraction of the arterial diameter. The grading consisted of a six point system with normal equal to grade 1 which was less than 5% thickening. Each additional grade consisted of 5% increments.

Tissues examined included adrenals, brain, liver, lung, pancreas and kidney, but not myocardium. Of all tissues examined only lung was statistically linked to smoking history. Most other tissues showed a statistically insignificant trend in the same direction.

There are three major criticisms which can be leveled at this paper. First, this group did not mention what methods

and criteria were used to exclude patients with known vascular sequelae. In addition, the size of the arteries examined was much larger than those vessels felt to be most closely allied to smoking history in previous studies. This fact made comparison between studies more difficult. Lastly, the measurement process itself is open to question since observer selection of lesions could lead to considerable variability. For all these reasons, the question of whether the kidney reflects the smoking history of the patient requires further analysis.

The impetus for investigating the kidney microvasculature rests on studies which define an age related intimal change in renal vessels (10,11,12). It has been suggested that these vascular changes are responsible for both the steadily decreasing glomerular filtration rate with age (13,14), as well as, abnormalities in renal blood flow studies (19,20). These vascular changes are strikingly similar to those lesions thought to be related to cigarette smoking. In addition, the Kaiser-Permanente health group has shown a correlation between urinalysis abnormalities and smoking history (42).

The weight of evidence suggests a peripheral vascular response to cigarette smoking. However, most studies have not developed the data in a quantitative, easily reproducible form. Naeye used quantitative methods, but was interested solely in the arteriolar media and was not measuring those vascular lesions implicated by previous studies. The present

investigation focuses on the small arteries and arterioles in both myocardium and kidney using planimetric analysis.

The myocardial vessels in smokers show a highly significant increase in intimal thickness in all arterioles examined ($P < 0.001$). This was true for all smokers when compared to non-smokers and when compared in age-matched groups.

The degree to which cigarette smoke affects the small arteries and arterioles in the myocardium is demonstrated by several lines of evidence. First, larger arterioles ($>150\mu$) in younger smokers were shown to have more intimal thickening than older non-smokers ($P < 0.05$). Smaller arterioles in smokers show similar changes but without the same statistical confidence. This data confirms past observations by Auerbach and argues to the significant effect of cigarette smoke on younger patients.

A demonstration of the dramatic effect of smoke on small vessels results from comparison of small versus large vessels within age and smoking groups. Non-smokers older than 60 show greater intimal proliferation in their small arterioles ($P < 0.05$). However, younger non-smokers show no significant difference between vessel size. This age related change in small vessel proliferative lesions is not seen in smokers since both groups show significant small vessel intimal changes. This argues, as did the previous data, that younger smokers show striking changes over their non-smoking counterparts.

Age changes were not well demonstrated when groups were controlled for smoking history. This may be explained in either of two ways. If the age changes noted in past studies are valid then perhaps this study had too few subjects to demonstrate such an effect. Type II error analysis suggests that this is true. Alternatively, there may be few if any small vessel changes with age. A larger group of subjects would clarify this point.

All of the smokers in this study had at least a one pack per day smoking habit. The relatively narrow difference between the reported smoking habits may explain the lack of correlation between the amount smoked and the extent of intimal proliferation. There were too few ex-smokers to reliably draw conclusions about this group.

Renal arterioles in smokers show a highly significant increase in intimal thickness for all vessels examined ($P < 0.001$). This was true of all smokers when compared to all non-smokers and when compared in age-matched groups. This represents the first confirmation of the significant effect of smoking on the renal vessels.

Examination of the relationship of small vessel intimal fibrous proliferation to larger vessels shows results quite different from that of the myocardium. In the kidney, both younger smokers and non-smokers show no significant difference. However, with increasing age, larger vessels show greater intimal thickening than small vessels. Thus there seems to be an age related increase in larger arteriole intimal proliferation which confirms past reports and is distinct from the effect of smoking.

Age comparison by smoking group for each arteriole size class is inconclusive and requires larger numbers of subjects. In the face of the preceding data, an age related change can be confidently stated. Examination of ex-smokers and regression analysis using smoking history and intimal proliferation all require larger numbers of subjects.

Conclusion

There are three major conclusions resulting from this study. First, cigarette smoking is highly associated with both renal and myocardial arteriolar intimal damage. This study is, therefore, the first confirmation of the effect of cigarette smoking on the renal microvasculature. Secondly, small arterioles in the myocardium show the greatest change with time in smokers. There are measurable age related changes in both renal and myocardial arterioles, with renal arterioles showing the most conclusive association with age.

While the relationships defined are highly significant and support past epidemiological, as well as anatomical studies concerning cigarette smoking, this study cannot prove causality. However, unlike past studies, this investigation has been highly selective concerning the subject population and can, therefore, associate cigarette smoking alone with vascular damage with a high degree of confidence.

The exact relationship of intimal damage to age and the extent of smoking history requires larger numbers of subjects. Indeed, the implication that, at least for

myocardium, the smallest vessels are most affected by smoking by-products is intriguing and would be better defined by larger number of subjects.

The next portion of this investigation would focus on the exact relationship of intimal damage to renal function changes with age and especially smoking habit. The correlation of glomerular filtration rate, in the form of creatinine clearance, with the extent of arteriolar intimal damage in smokers might define at least a subgroup of patients whose renal function is adversely affected by cigarette smoking.

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APPENDIX I

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
#1	250	105.6	423.8	690.4	0.066	318.2	584.8	0.544	AVG.-0.43
A78-43	400	1228.6	1808.7	2958.4	0.102	580.1	1729.8	0.335	<150-0.43
MYO.:	400	106.4	201.8	353.7	0.041	95.4	247.3	0.386	>150- --
	400	917.1	1519.1	2302.2	0.077	602.0	1385.1	0.435	
#1	250	513.3	1081.3	1767.6	0.169	568.0	1254.3	0.453	AVG.-0.52
A78-43	250	32.9	55.8	96.2	0.040	22.9	63.3	0.362	<150-0.41
KID.:	400	725.7	1500.2	2301.3	0.116	774.5	1575.6	0.492	>150-0.60
	100	242.8	816.7	1023.7	0.325	573.9	780.9	0.735	
	400	222.5	318.4	512.7	0.063	95.9	290.2	0.330	
	100	353.3	849.8	1308.2	0.295	496.5	954.9	0.520	
	250	850.9	1616.5	2192.3	0.170	765.6	1341.4	0.571	
	100	578.2	2130.2	2962.4	0.357	1552.0	2384.2	0.651	
	250	740.3	1805.6	2373.1	0.218	1065.3	1632.8	0.652	
	400	513.3	701.8	928.2	0.073	188.5	414.9	0.454	
#2	400	59.7	150.7	248.4	0.040	91.0	188.7	0.482	AVG.-0.44
A78-36	250	545.6	1079.7	1611.5	0.138	534.1	1065.9	0.501	150-0.44
MYO.:	250	68.4	428.0	1142.9	0.095	359.6	1074.5	0.335	150- --
#2	250	1152.8	1939.4	2493.3	0.181	786.6	1340.5	0.587	AVG.-0.48
A78-36	250	1385.0	2432.5	3935.2	0.203	1047.5	2550.2	0.411	150- --
KID.:	100	1144.8	1984.5	2823.5	0.575	839.7	1678.7	0.500	150-0.48
	100	286.2	497.4	759.1	0.270	211.2	472.9	0.447	
	100	264.5	432.1	610.1	0.231	167.6	345.6	0.485	
	100	469.2	789.1	1143.8	0.312	319.9	674.6	0.474	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
#3	100	1390.7	1605.4	3061.0	0.401	214.7	1670.3	0.129	AVG.-0.36
A78-70	400	515.3	747.6	1104.7	0.082	232.3	589.4	0.394	<150-0.40
MYO.:	250	1807.2	2711.4	3677.8	0.237	904.2	1870.6	0.483	>150-0.31
	400	277.8	413.2	582.7	0.070	135.4	304.9	0.444	
	400	166.8	374.7	760.7	0.052	207.9	593.9	0.350	
#3	400	1904.8	2998.2	4961.1	0.156	1093.4	3056.3	0.358	AVG.-0.41
A78-70	250	528.3	1466.6	2829.9	0.158	938.3	2301.6	0.408	<150-0.31
KID.:	400	2546.7	4084.4	5720.3	0.182	1537.7	3173.6	0.485	>150-0.45
	400	101.0	208.7	447.6	0.065	107.7	346.6	0.311	
	400	1796.9	3167.0	4316.0	0.156	1370.1	2519.1	0.544	
	100	519.5	858.1	1535.5	0.442	338.6	1016.0	0.333	
	100	722.0	1153.7	1703.8	0.398	413.7	981.8	0.440	
#4	400	304.1	1107.6	1351.3	0.081	803.5	1047.2	0.767	AVG.-0.59
A78-62	400	187.6	414.2	575.5	0.057	226.6	387.9	0.584	<150-0.66
MYO.:	400	126.3	574.0	807.9	0.064	447.7	681.6	0.657	>150-0.33
	250	363.9	756.9	992.3	0.089	393.0	628.4	0.625	
	100	555.4	926.0	1682.7	0.255	370.6	1127.3	0.329	
#4	250	723.9	1254.4	1872.5	0.174	530.5	1148.6	0.462	AVG.-0.42
A78-62	100	315.0	558.8	749.9	0.192	243.8	434.9	0.561	<150-0.38
KID.:	250	1082.8	2035.7	3312.8	0.238	952.9	2230.0	0.427	>150-0.43
	400	70.0	174.8	313.5	0.060	104.8	243.5	0.430	
	400	335.3	493.8	814.3	0.076	158.5	479.0	0.331	
	100	607.3	1065.4	1713.0	0.384	458.1	1105.7	0.414	
	100	735.6	1164.7	1840.3	0.304	429.1	1104.7	0.388	
	100	354.3	547.9	953.0	0.241	193.6	598.7	0.323	
#5	100	320.2	479.0	1055.3	0.323	158.8	735.1	0.216	AVG.-0.38
A78-42	400	1256.0	1707.0	2213.2	0.140	451.0	957.2	0.471	<150-0.43
MYO.:	250	138.9	288.6	438.8	0.081	149.7	299.9	0.499	>150-0.29
	400	205.2	689.9	1250.9	0.084	484.7	1045.7	0.464	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
#5	100	447.3	680.9	1075.0	0.256	233.6	627.7	0.372	
A78-42	400	294.2	519.8	1112.1	0.083	225.6	817.9	0.276	
MYO.:									
#5	100	808.1	1198.1	1778.0	0.391	390.0	969.9	0.402	AVG.-0.55
A78-42	400	1839.0	4052.6	5474.0	0.197	2213.6	3635.0	0.609	<150-0.61
KID.:	250	1073.2	1783.7	2473.4	0.213	710.5	1400.2	0.508	>150-0.54
	400	268.5	606.2	823.8	0.076	337.7	555.3	0.608	
	100	456.3	1042.7	1405.4	0.270	586.4	949.1	0.618	
	100	157.6	503.3	794.9	0.289	345.7	637.3	0.542	
#6	400	475.2	594.9	812.1	0.055	119.7	336.9	0.355	AVG.-0.46
A78-45	400	203.8	281.3	366.7	0.045	77.5	162.9	0.476	<150-0.46
MYO.:	400	501.7	724.8	954.5	0.067	223.1	452.8	0.493	>150- --
	400	572.0	861.2	1150.5	0.057	289.2	578.5	0.500	
	400	164.7	512.9	939.3	0.047	348.2	774.6	0.450	
	400	775.7	1277.7	2014.5	0.086	502.0	1238.8	0.405	
	250	241.6	624.6	1065.6	0.112	383.0	824.0	0.465	
	400	642.5	1467.6	2256.3	0.071	825.1	1613.8	0.511	
#6	100	417.0	695.5	1063.9	0.319	278.5	646.9	0.431	AVG.-0.46
A78-45	250	645.5	1000.0	1560.8	0.109	354.5	915.3	0.387	<150-0.55
KID.:	250	1803.5	2870.7	4207.0	0.232	1067.2	2403.5	0.444	>150-0.41
	400	76.5	248.8	356.3	0.050	172.3	279.8	0.616	
	400	76.2	281.5	394.2	0.055	205.3	318.0	0.646	
	250	1082.4	1466.0	2255.7	0.201	383.6	1173.3	0.327	
	100	537.3	800.6	1211.7	0.297	263.3	674.4	0.390	
	100	661.1	952.1	1275.8	0.369	291.0	614.7	0.473	
#7	100	152.0	495.9	1071.9	0.287	343.9	919.9	0.374	AVG.-0.45
A78-39	100	222.7	521.0	788.8	0.224	298.3	566.1	0.527	<150-0.45
MYO.:	400	552.4	787.6	1072.9	0.069	235.2	520.5	0.452	>150-0.45
	400	975.1	1269.7	1640.7	0.104	294.6	665.6	0.443	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
#7	400	959.0	1512.3	2468.8	0.122	553.3	1509.8	0.366	AVG.-0.54
A78-39	400	829.3	1614.4	2451.6	0.080	785.1	1622.3	0.484	<150-0.37
KID.:	100	837.8	1761.3	2091.5	0.375	923.5	1253.7	0.740	>150-0.63
	250	2238.3	3589.3	4900.0	0.254	1351.0	2661.7	0.508	
	100	1172.0	2111.1	2640.8	0.613	939.1	1468.8	0.639	
	400	561.5	1325.4	2053.1	0.107	763.9	1491.6	0.512	
#8	400	539.1	873.9	1503.7	0.087	334.8	1964.6	0.347	AVG.-0.40
A78-86	400	24.4	60.7	98.5	0.018	36.3	74.1	0.490	<150-0.40
MYO.:	400	91.6	149.8	283.4	0.041	58.2	191.8	0.303	>150- --
	400	218.5	337.0	605.8	0.052	118.5	387.3	0.306	
	400	258.8	769.3	1211.9	0.062	510.5	953.1	0.534	
	400	1390.5	1691.7	2506.0	0.109	301.2	1115.5	0.270	
	400	189.4	357.2	548.7	0.061	167.8	359.3	0.467	
	400	14.2	41.0	72.4	0.020	26.8	58.2	0.460	
#8	400	1000.9	2214.3	3176.2	0.126	1213.4	2175.3	0.358	AVG.-0.50
A78-86	100	366.9	942.0	1706.8	0.408	575.1	1339.9	0.429	<150-0.43
KID.:	100	348.9	810.3	1137.7	0.260	461.4	788.8	0.585	>150-0.53
	250	1404.8	2176.2	3162.3	0.236	771.4	1757.5	0.439	
	400	52.7	147.8	244.3	0.035	95.1	191.6	0.496	
	250	679.4	2131.5	2819.7	0.219	1452.1	2140.3	0.678	
#9	400	1339.0	3169.2	4043.5	0.135	1830.2	2704.5	0.677	AVG.-0.36
A78-54	400	123.9	231.1	427.6	0.056	107.2	303.7	0.353	<150-0.37
MYO.:	400	49.1	131.2	314.1	0.041	82.1	265.0	0.310	>150-0.29
	400	31.1	75.3	161.5	0.033	44.2	130.4	0.339	
	250	241.9	422.8	800.2	0.056	180.9	558.3	0.324	
	400	118.7	300.5	633.1	0.059	181.8	514.4	0.353	
	400	436.7	934.5	1765.0	0.080	497.8	1328.3	0.375	
	250	600.1	1162.5	2232.1	0.214	562.4	1632.0	0.345	
	250	387.3	905.6	2679.9	0.158	518.3	2292.6	0.226	
	250	686.0	1326.3	2404.1	0.144	640.2	1718.1	0.373	
	250	327.7	491.8	974.1	0.121	164.1	646.4	0.254	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
#9	400	267.9	398.6	581.2	0.062	130.7	313.3	0.417	AVG.-0.48
A78-54	400	614.7	983.1	1752.4	0.106	368.4	1137.7	0.324	<150-0.37
KID.:	100	514.5	1067.8	1643.5	0.477	553.3	1129.0	0.490	>150-0.53
	100	210.7	477.4	732.7	0.263	266.7	522.0	0.511	
	100	449.1	757.7	969.0	0.326	308.6	519.9	0.594	
	100	272.3	654.9	986.2	0.327	382.6	713.9	0.536	
#10	400	324.8	755.1	1194.9	0.079	430.3	870.1	0.495	AVG.-0.41
A78-72	400	121.6	172.1	265.2	0.038	50.5	143.6	0.352	<150-0.45
MYO.:	400	1322.1	2114.1	3067.6	0.101	792.0	1745.5	0.454	>150-0.30
	400	83.5	214.9	280.5	0.043	131.4	197.0	0.667	
	250	2750.5	3167.7	4080.1	0.217	417.2	1329.6	0.314	
	250	1160.0	1353.1	1819.4	0.197	193.1	659.4	0.293	
	400	749.3	1000.3	1383.5	0.096	251.0	634.2	0.396	
	400	87.8	194.7	403.1	0.026	106.9	315.3	0.339	
#10	400	1685.6	3848.7	5454.0	0.175	2163.1	3768.4	0.574	AVG.-0.42
A78-72	400	107.7	177.2	363.2	0.049	69.5	255.5	0.272	<150-0.38
KID.:	250	1081.1	1773.3	2402.9	0.150	692.2	1321.8	0.524	>150-0.51
	400	69.9	129.9	198.1	0.038	60.0	128.2	0.468	
	400	46.7	101.1	208.3	0.037	54.4	161.6	0.337	
	400	108.0	166.4	258.8	0.043	58.4	150.8	0.387	
	250	716.2	1163.0	1688.3	0.130	448.8	972.1	0.460	
	250	511.8	791.3	1319.3	0.105	279.5	807.5	0.346	
	100	654.9	1059.7	1566.7	0.319	404.8	911.8	0.444	
#11	400	287.0	385.5	644.4	0.049	98.5	357.4	0.276	AVG.-0.39
A78-85	100	568.7	687.0	1037.5	0.305	118.3	468.8	0.252	<150-0.46
MYO.:	250	2080.7	2334.2	2694.7	0.201	253.5	614.0	0.413	>150-0.32
	400	228.3	343.7	524.8	0.077	115.4	296.5	0.389	
	400	31.2	64.3	134.7	0.031	33.1	103.5	0.320	
	400	26.1	86.7	96.3	0.019	60.6	70.2	0.863	
	250	1142.7	1456.2	2241.7	0.180	313.5	1099.0	0.285	
	250	1053.6	1279.5	1717.7	0.169	225.9	664.1	0.340	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., 150, 150
#11	100	704.0	1232.8	1823.7	0.195	528.8	1119.7	0.472	AVG.-0.51
A78-85	400	665.7	1125.3	1425.5	0.087	459.6	759.8	0.605	150-0.51
KID.:	250	541.4	1409.1	1792.7	0.171	867.7	1251.3	0.693	150-0.52
	100	451.6	713.3	1063.0	0.222	261.7	611.4	0.428	
	100	605.2	973.7	1374.2	0.292	368.5	769.0	0.479	
	400	398.7	723.9	1170.5	0.087	325.2	771.8	0.421	
	400	788.3	1404.4	2042.7	0.101	616.1	1254.4	0.491	
#12	400	17.2	37.6	80.5	0.020	20.4	63.3	0.322	AVG.-0.39
A78-63	400	12.8	30.3	52.3	0.010	17.5	39.5	0.443	150-0.41
MYO.:	400	8.0	27.0	47.7	0.013	19.0	39.7	0.479	150-0.27
	250	588.1	1219.3	2153.2	0.092	631.2	1565.1	0.403	
	400	126.7	226.9	305.9	0.039	100.2	179.2	0.559	
	400	103.6	171.7	252.5	0.042	68.1	148.9	0.457	
	400	813.1	1092.5	1594.3	0.086	279.4	781.2	0.358	
	400	445.1	634.1	1063.2	0.099	189.0	618.1	0.306	
	400	253.5	425.3	703.3	0.080	171.8	449.8	0.382	
	100	408.6	470.8	642.4	0.216	62.2	233.8	0.266	
	100	384.5	470.7	695.5	0.210	86.2	311.0	0.277	
#12	400	32.3	120.3	164.8	0.035	88.0	132.5	0.664	AVG.-0.51
A78-63	400	1110.3	2173.2	3001.4	0.112	1062.9	1891.1	0.562	150-0.56
KID.:	250	1877.7	2925.6	4047.4	0.185	1047.9	2170.0	0.483	150-0.46
	250	753.8	1274.7	1866.5	0.177	520.9	1112.7	0.468	
	250	908.0	1694.4	2767.8	0.209	786.4	1859.8	0.423	
	400	47.0	101.5	168.8	0.041	54.5	121.8	0.447	
#13	400	481.4	937.9	1406.5	0.063	456.5	925.1	0.493	AVG.-0.40
A78-46	100	147.9	364.8	1032.7	0.231	216.9	884.8	0.245	150-0.45
MYO.:	400	260.8	1047.0	2292.6	0.089	786.2	2031.8	0.387	150-0.25
	400	84.7	533.8	1041.3	0.064	449.1	956.6	0.469	
#13	400	623.1	962.6	1455.1	0.037	339.5	832.0	0.408	AVG.-0.50
A78-46	250	722.1	951.6	1223.3	0.145	229.5	501.2	0.458	150-0.48
KID.:	250	544.5	1015.7	1366.7	0.135	471.2	822.2	0.573	150-0.55
	100	519.1	1049.0	1491.2	0.422	529.9	972.1	0.545	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
#14	400	223.9	1218.5	1891.2	0.077	994.6	1667.3	0.597	AVG.-0.43
A78-69	400	840.8	1530.0	2747.7	0.104	689.2	1906.9	0.361	<150-0.47
MYO.:	400	546.3	933.8	1358.2	0.107	387.5	811.9	0.477	>150-0.25
	400	150.4	326.2	552.0	0.047	175.8	401.6	0.438	
	250	539.3	1026.7	2461.2	0.181	487.4	1921.9	0.254	
#14	100	386.0	587.6	1018.5	0.267	201.6	632.5	0.319	AVG.-0.36
A78-69	250	1077.8	2041.0	3138.5	0.207	963.2	2060.7	0.467	<150-0.37
KID.:	400	1106.9	1939.3	2845.7	0.131	832.4	1738.8	0.479	>150-0.35
	250	1100.7	1717.4	2693.3	0.189	616.7	1592.6	0.387	
	250	35.5	56.8	136.5	0.053	21.3	101.0	0.211	
	250	32.5	67.5	157.2	0.048	35.0	124.7	0.281	
	250	1780.4	2190.9	3471.3	0.209	410.5	1690.9	0.243	
	400	1573.5	2483.9	3322.7	0.139	910.4	1749.2	0.520	
#15	400	40.2	105.3	233.2	0.047	65.1	193.0	0.337	AVG.-0.31
A78-57	400	97.1	140.4	247.1	0.043	43.3	150.0	0.289	<150-0.31
MYO.:	400	457.0	712.9	1314.6	0.059	255.9	857.6	0.298	>150- --
#15	100	1093.1	2121.3	2932.3	0.533	1028.2	1839.2	0.559	AVG.-0.45
A78-57	250	121.4	285.1	654.4	0.116	163.7	533.0	0.307	<150-0.42
KID.:	400	47.5	89.9	157.4	0.046	42.4	109.9	0.386	>150-0.56
	400	821.9	1539.0	2145.2	0.101	717.1	1323.3	0.542	
#16	400	1946.4	2440.9	3759.3	0.123	494.5	1812.9	0.273	AVG.-0.34
A78-53	400	247.3	394.3	638.3	0.063	147.0	391.0	0.376	<150-0.34
MYO.:	400	34.5	64.8	129.0	0.026	30.3	94.5	0.321	>150-0.24
	400	17.7	34.0	56.2	0.017	16.3	38.5	0.423	
	400	19.5	40.2	59.7	0.018	20.7	40.2	0.515	
	400	61.6	99.9	140.3	0.022	38.3	78.7	0.487	
	250	582.9	879.8	1503.9	0.106	298.9	921.0	0.322	
	400	428.8	744.1	1338.0	0.072	315.3	909.2	0.347	
	400	699.5	1088.6	2205.7	0.095	389.1	1506.2	0.258	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
	400	89.0	160.4	300.6	0.040	71.4	211.6	0.337	
	400	426.6	766.1	1513.1	0.085	339.5	1086.5	0.312	
	250	463.3	1199.5	3844.2	0.117	736.2	3380.9	0.218	
	400	324.7	609.1	1165.9	0.067	284.4	841.2	0.338	
	250	819.2	1201.2	2418.5	0.157	382.0	1599.3	0.239	
	400	136.1	277.4	615.1	0.053	141.3	479.0	0.295	
#16	250	1242.6	2130.8	2366.4	0.158	888.2	1123.8	0.790	AVG.-0.62
A78-53	250	809.1	1482.8	1874.7	0.160	673.7	1065.6	0.632	<150-0.57
KID.:	250	1690.5	2451.0	2824.0	0.210	760.5	1133.5	0.671	>150-0.64
	250	786.1	1320.3	1627.1	0.159	534.2	841.0	0.635	
	100	344.5	590.2	851.0	0.270	245.7	506.5	0.485	
	400	57.3	105.1	135.7	0.035	47.8	78.4	0.610	
	400	49.1	96.8	139.3	0.029	47.7	90.2	0.529	
#17	400	537.0	708.7	889.5	0.081	171.7	352.5	0.49	AVG.-0.39
A78-79	400	323.4	386.6	528.4	0.053	63.2	205.0	0.31	<150-0.39
MYO.:	400	869.8	1557.6	2479.8	0.091	687.8	1610.0	0.43	>150-0.37
	400	40.6	82.4	144.2	0.031	41.8	103.6	0.40	
	250	681.2	874.2	1277.1	0.124	193.0	595.9	0.32	
	250	823.9	1022.0	1355.9	0.155	198.1	532.0	0.37	
	400	374.7	641.5	1041.3	0.065	266.8	666.6	0.40	
#17	400	33.2	58.2	147.7	0.046	25.0	114.5	0.218	AVG.-0.34
A78-79	400	279.3	564.0	1379.3	0.063	284.7	1100.0	0.259	<150-0.30
KID.:	250	160.8	559.2	1512.3	0.105	398.4	1351.5	0.295	>150-0.44
	250	1557.4	3135.7	4563.8	0.286	1578.3	3006.4	0.525	
	400	84.2	124.0	259.9	0.076	39.8	175.7	0.227	
	250	1337.6	1626.9	2500.3	0.160	289.3	1162.7	0.248	
	250	1109.5	1474.5	2929.9	0.132	365.0	1820.4	0.201	
	400	25.7	86.5	136.0	0.035	60.8	110.3	0.551	
	400	55.0	88.1	145.9	0.036	33.1	90.9	0.364	
	250	745.0	1778.9	2630.8	0.195	1033.9	1885.8	0.548	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
#18	400	476.1	586.5	945.5	0.074	110.4	469.4	0.235	AVG.-0.36
A78-78	400	487.6	1035.0	1622.2	0.073	547.4	1134.6	0.482	<150-0.35
MYO.:	400	110.5	164.1	272.9	0.036	53.6	162.4	0.330	>150-0.38
	400	171.7	319.8	573.9	0.036	148.1	402.2	0.368	
	250	1185.5	1646.7	2387.6	0.209	461.2	1202.1	0.384	
	250	418.9	662.9	1127.8	0.080	244.0	708.9	0.344	
#18	400	523.0	1090.5	1734.8	0.087	567.5	1211.8	0.468	AVG.-0.39
A78-78	400	472.9	792.8	1435.2	0.090	319.9	962.3	0.332	<150-0.36
KID.:	400	450.9	696.3	1192.3	0.085	245.4	741.4	0.331	>150-0.52
	400	379.0	586.0	881.5	0.061	207.0	502.5	0.412	
	400	689.7	1038.6	1992.6	0.084	348.9	1302.9	0.268	
	250	1012.1	2073.0	3054.7	0.176	1060.9	2042.6	0.519	
#19	100	412.3	485.7	854.0	0.272	73.4	441.7	0.166	AVG.-0.30
A78-64	400	305.2	459.2	758.1	0.060	154.0	452.9	0.340	<150-0.39
MYO.:	100	441.5	730.0	1643.5	0.172	288.5	1202.0	0.240	>150-0.24
	250	879.0	1223.4	1994.3	0.164	344.4	1115.3	0.309	
	400	2509.7	3775.8	5392.8	0.148	1266.1	2883.1	0.439	
#19	400	401.2	1197.4	1682.1	0.082	796.2	1280.9	0.622	AVG.-0.50
A78-64	250	762.6	1263.2	1790.9	0.184	500.6	1028.3	0.487	<150-0.54
KID.:	250	1480.3	2402.7	3255.8	0.177	922.4	1775.3	0.520	>150-0.46
	400	468.3	936.7	1690.7	0.090	468.4	1222.4	0.383	
	100	758.8	1559.6	2341.1	0.390	800.8	1582.3	0.506	
	250	454.7	882.8	1246.6	0.110	428.1	791.9	0.541	
	100	823.4	1276.4	2245.7	0.432	453.0	1422.3	0.318	
	250	544.6	1364.0	1890.6	0.129	819.4	1346.0	0.609	
#20	400	215.2	703.1	812.4	0.054	487.9	597.2	0.817	AVG.-0.50
A78-37	400	509.4	920.9	1472.0	0.054	411.5	926.6	0.427	<150-0.59
MYO.:	400	836.8	1863.9	2379.4	0.126	1027.1	1542.6	0.666	>150-0.32
	100	87.6	166.3	429.9	0.189	78.7	342.3	0.230	
	250	265.7	706.4	1229.0	0.096	440.7	963.3	0.457	
	100	164.8	358.2	635.4	0.209	193.4	470.6	0.411	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
#20	250	1038.2	1427.8	2195.8	0.163	389.6	1157.6	0.337	AVG.-0.44
A78-37	400	182.1	619.2	986.8	0.065	437.1	804.8	0.543	<150-0.50
KID.:	400	92.1	452.8	815.9	0.076	360.7	723.8	0.498	>150-0.38
	400	81.8	192.4	319.0	0.044	110.6	237.2	0.466	
	100	460.4	649.5	869.4	0.290	189.1	409.0	0.462	
	250	1019.5	1427.4	2187.7	0.168	407.9	1168.2	0.349	
#21	400	245.5	311.5	603.6	0.030	66.0	358.1	0.184	AVG.-0.22
A78-55	400	258.1	297.2	595.0	0.053	39.1	336.9	0.116	<150-0.22
MYO.:	400	198.2	257.0	446.5	0.058	58.8	248.3	0.100	>150- --
	400	1211.1	1403.3	2215.3	0.121	192.2	1004.2	0.191	
	400	78.1	100.2	155.1	0.034	22.1	77.0	0.287	
	400	529.8	639.1	771.8	0.073	109.3	242.0	0.452	
#21	250	1567.3	2653.5	3629.3	0.213	1086.2	2062.0	0.527	AVG.-0.41
A78-55	100	529.7	977.1	1436.5	0.394	447.4	906.8	0.493	<150- --
KID.:	100	966.3	1475.7	2470.9	0.429	509.4	1504.6	0.339	>150-0.41
	100	1463.0	2257.7	3517.7	0.359	794.7	2054.7	0.387	
	100	800.6	1185.2	2084.3	0.394	384.6	1283.7	0.300	
#22	400	128.6	237.8	346.1	0.033	109.2	217.5	0.502	AVG.-0.43
A78-51	400	350.3	563.0	796.4	0.065	212.7	446.1	0.477	<150-0.43
MYO.:	250	598.9	1231.5	2455.5	0.106	632.6	1856.6	0.341	>150- --
	400	926.1	1276.3	1851.9	0.096	350.2	925.8	0.378	
#22	400	589.4	1625.2	2502.8	0.127	1035.8	1913.4	0.541	AVG.-0.54
A78-51	250	1050.6	2313.0	3381.9	0.197	1262.4	2331.3	0.542	<150-0.54
KID.:	100	350.7	596.6	837.9	0.300	245.9	487.2	0.505	>150-0.54
	250	993.6	2329.9	3297.1	0.227	1336.3	2303.5	0.580	
	100	475.1	900.0	1081.2	0.234	424.9	606.1	0.701	
	250	962.3	1579.3	2351.4	0.163	617.0	1389.1	0.444	
	100	350.5	644.1	948.4	0.317	293.6	597.9	0.491	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
#23	250	1779.3	2260.6	3366.2	0.150	481.3	1586.9	0.303	AVG.-0.34
A78-41	250	645.9	870.4	1395.4	0.117	224.3	1395.4	0.161	<150-0.38
MYO.:	400	45.9	167.8	296.4	0.044	121.9	250.5	0.487	>150-0.25
	250	374.0	671.0	1823.1	0.150	297.0	1449.1	0.205	
	400	86.8	162.0	264.6	0.034	75.2	177.8	0.423	
	400	323.3	564.0	1063.7	0.062	240.7	740.4	0.325	
	250	177.7	369.3	562.7	0.063	191.6	385.0	0.498	
#23	100	219.4	583.2	730.3	0.155	363.8	510.9	0.712	AVG.-0.51
A78-41	250	600.5	1104.2	1626.6	0.156	503.7	1026.1	0.491	<150-0.53
KID.:	250	803.4	1266.4	1811.3	0.145	463.0	1007.9	0.459	>150-0.50
	100	377.0	579.1	835.5	0.282	202.1	458.5	0.441	
	100	261.8	480.2	867.9	0.238	218.4	606.1	0.360	
	400	322.3	956.7	1375.1	0.097	634.4	1052.8	0.603	
#24	250	137.6	355.6	627.8	0.064	218.0	490.2	0.445	AVG.-0.50
A78-68	400	62.4	203.6	277.2	0.070	141.2	214.8	0.657	<150-0.53
MYO.:	400	548.3	1019.0	1490.5	0.071	470.7	942.2	0.500	>150-0.40
	250	1206.3	1850.7	2811.5	0.154	644.4	1605.2	0.401	
#24	250	1254.1	1940.3	2568.3	0.203	686.2	1314.2	0.522	AVG.-0.31
A78-68	250	775.2	1021.5	1801.3	0.167	246.3	1026.1	0.240	<150-0.29
KID.:	250	688.4	820.9	1275.9	0.132	132.5	587.5	0.255	>150-0.34
	400	1551.9	1899.2	2941.0	0.136	347.3	385.1	0.250	
	250	564.2	803.1	1318.5	0.104	238.9	754.3	0.317	
	250	1458.1	2498.2	4097.6	0.210	1040.1	2639.5	0.394	
	400	96.2	156.7	308.6	0.045	60.5	212.4	0.285	
	400	986.2	1508.6	2503.8	0.143	522.4	1517.6	0.344	
	250	1449.9	1754.0	3080.5	0.158	304.1	1630.6	0.186	
#25	400	1315.2	1591.1	1867.2	0.099	275.9	552.0	0.500	AVG.-0.45
A78-48	400	534.9	649.4	822.8	0.072	114.5	287.9	0.398	<150-0.45
MYO.:									>150- --

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
#25	250	1015.4	1717.0	2796.1	0.178	701.6	1780.7	0.394	AVG.-0.35
A78-48	100	308.6	410.3	541.8	0.213	101.7	233.2	0.436	<150-0.29
KID.:	250	801.9	1010.2	1481.3	0.149	208.3	679.4	0.307	>150-0.42
	250	1122.7	1501.2	2512.1	0.134	378.8	1389.4	0.273	
#26	250	395.2	674.3	1158.8	0.096	279.1	763.6	0.37	AVG.-0.35
26000	250	283.3	438.7	741.2	0.105	155.4	457.9	0.34	<150-0.35
MYO.:	400	71.4	131.5	184.1	0.031	60.1	112.7	0.53	>150- --
	400	351.8	616.9	1257.2	0.059	265.1	905.4	0.29	
	400	950.6	1760.9	3392.6	0.124	810.3	2442.0	0.33	
	250	55.6	78.3	141.3	0.036	22.7	85.7	0.26	
#26	100	326.2	645.0	994.0	0.286	318.8	667.8	0.47	AVG.-0.48
26000	400	51.6	98.1	190.8	0.037	46.5	139.2	0.33	<150-0.36
KID.:	400	146.7	317.9	619.4	0.068	171.2	472.7	0.36	>150-0.61
	100	364.1	769.3	1020.7	0.252	405.2	656.6	0.62	
	100	597.1	1479.0	2151.2	0.572	881.9	1554.1	0.57	
	400	523.8	1334.7	1943.1	0.108	810.9	1419.3	0.57	
	250	597.4	1788.1	2133.7	0.177	1190.7	1536.3	0.77	
	400	28.3	47.6	149.5	0.029	19.3	121.2	0.16	
#27	100	293.9	367.3	590.3	0.187	73.4	296.4	0.25	AVG.-0.29
26248	400	26.6	64.6	115.9	0.026	38.0	89.3	0.43	<150-0.32
MYO.:	400	208.1	296.9	455.8	0.043	88.8	247.7	0.36	>150-0.22
	250	760.2	1033.3	1879.7	0.100	273.1	1119.5	0.24	
	250	820.2	980.6	1721.1	0.151	160.4	900.9	0.18	
	250	739.5	1139.1	2190.9	0.106	399.6	1451.4	0.28	
	400	1476.6	1922.9	3035.9	0.110	446.3	1559.3	0.29	
#27	400	86.1	135.5	304.5	0.039	49.4	218.4	0.23	AVG.-0.32
26248	400	76.2	108.3	197.1	0.038	32.1	120.9	0.27	<150-0.29
KID.:	400	74.3	116.2	233.2	0.030	41.9	158.9	0.26	>150-0.46
	400	56.8	80.2	187.6	0.033	23.4	130.8	0.18	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
	400	397.4	654.9	956.8	0.058	257.5	559.4	0.46	
	400	108.7	152.3	260.9	0.044	43.6	152.2	0.29	
	400	183.2	406.1	908.4	0.086	222.9	725.2	0.31	
	400	27.3	65.7	213.2	0.042	38.4	185.9	0.21	
	400	313.8	841.5	1569.6	0.095	527.7	1255.8	0.42	
	250	283.1	483.9	1112.8	0.116	200.8	829.7	0.24	
	250	548.3	1157.1	1726.9	0.157	608.9	1178.7	0.51	
	100	706.9	1479.2	2646.8	0.396	772.3	1939.9	0.40	
#28	400	505.7	863.4	1578.1	0.069	357.7	1072.4	0.334	AVG.-0.42
A78-88	400	75.4	162.1	319.4	0.038	86.7	244.0	0.355	<150-0.42
MYO.:	400	79.5	292.7	498.7	0.034	213.2	419.2	0.509	>150- --
	400	601.7	1154.9	2057.9	0.089	553.2	1456.2	0.380	
	400	53.8	158.7	286.9	0.037	104.9	233.1	0.450	
	400	37.3	98.7	152.5	0.029	61.4	115.2	0.533	
	250	289.5	427.1	699.2	0.092	137.6	409.7	0.336	
	250	103.9	183.2	274.7	0.081	79.3	170.8	0.464	
	400	41.4	98.2	194.2	0.027	56.8	152.8	0.372	
#28	400	700.8	1659.9	2393.0	0.110	959.1	1692.2	0.567	AVG.-0.43
A78-88	250	640.8	1664.6	2660.1	0.222	1023.8	2019.3	0.507	<150-0.47
KID.:	250	640.1	1259.7	2256.1	0.188	619.6	1616.0	0.383	>150-0.38
	250	323.7	857.0	1365.7	0.167	533.3	1042.0	0.201	
	250	149.8	427.0	866.3	0.136	277.2	716.5	0.387	
	400	498.0	1136.2	2874.9	0.143	638.2	2376.9	0.269	
	400	153.0	899.5	1441.4	0.097	746.5	1288.4	0.579	
	400	914.5	2178.7	4006.1	0.155	1264.2	3091.6	0.409	
	400	92.8	186.2	284.0	0.040	93.4	191.2	0.488	
	400	124.8	221.1	314.8	0.044	96.3	190.0	0.507	
#29	100	257.1	388.1	782.6	0.351	131.0	529.5	0.25	AVG.-0.24
26169	400	573.2	700.3	1042.3	0.078	127.1	469.1	0.27	<150-0.25
MYO.:	400	141.5	185.9	296.0	0.036	44.4	154.5	0.29	>150-0.23

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
	100	417.7	525.1	906.3	0.244	107.4	488.6	0.22	
	250	1827.8	2336.5	4148.8	0.170	508.7	2321.0	0.22	
	400	87.4	120.9	198.0	0.031	33.5	110.6	0.30	
	400	37.3	45.3	104.0	0.023	8.0	66.7	0.12	
#29	100	486.3	965.6	1525.2	0.382	479.3	1038.9	0.46	AVG.-0.32
26169	400	259.6	348.9	555.4	0.068	89.3	295.8	0.30	<150-0.29
KID.:	100	289.3	471.6	681.5	0,289	182.3	392.2	0.46	>150-0.38
	400	61.3	82.7	157.1	0.035	21.4	95.8	0.22	
	400	123.4	170.3	227.7	0.034	46.9	104.3	0.45	
	400	81.1	117.6	250.4	0.034	36.5	169.3	0.22	
	100	516.8	755.5	1253.7	0.357	238.7	736.9	0.32	
	400	64.8	98.3	192.7	0.353	33.5	127.9	0.26	
	400	915.3	1545.6	2637.4	0.130	600.3	1722.1	0.35	
	400	40.1	69.2	182.7	0.030	29.1	142.6	0.20	
#30	400	167.3	333.7	711.1	0.077	166.4	543.8	0.31	AVG.-0.26
26014	400	299.9	434.7	747.9	0.073	134.8	448.0	0.30	<150-0.30
MYO.:	100	474.9	754.7	1742.4	0.236	279.8	1267.5	0.22	>150-0.19
	400	292.2	499.0	950.3	0.059	206.8	658.1	0.31	
	100	389.3	454.0	816.2	0.269	64.7	426.9	0.15	
	400	267.3	609.8	1589.4	0.075	342.5	1322.1	0.16	
#30	250	543.9	939.0	1332.1	0.152	395.1	788.2	0.50	AVG.-0.37
26014	400	169.3	213.5	337.6	0.051	44.2	168.3	0.26	<150-0.29
KID.:	400	625.5	775.8	1220.5	0.086	150.3	595.0	0.25	>150-0.47
	400	79.1	139.5	264.8	0.044	60.4	185.7	0.33	
	100	1753.0	2675.6	3775.2	0.654	922.6	2022.2	0.46	
	400	118.7	227.4	456.3	0.049	108.7	337.6	0.32	
	250	866.5	1624.0	2572.2	0.202	757.5	1705.7	0.44	
#31	400	1497.4	2155.7	3238.2	0.106	658.3	1740.8	0.378	AVG.-0.42
A78-71	400	165.2	346.8	956.7	0.058	181.6	791.5	0.229	150-0.42
MYO.:	400	37.0	91.7	165.3	0.027	54.7	128.3	0.426	150- --

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
	400	234.8	418.8	749.6	0.049	184.0	514.8	0.357	
	400	61.5	162.2	255.7	0.030	100.7	194.2	0.519	
	400	181.7	543.2	921.3	0.076	361.5	739.6	0.489	
	400	5.2	24.0	39.5	0.019	18.8	34.3	0.548	
	400	7.1	22.1	46.0	0.021	15.0	38.9	0.386	
#31	100	540.0	750.6	1382.6	0.422	210.6	842.6	0.250	AVG.-0.32
A78-71	100	297.1	518.4	992.6	0.261	221.3	695.5	0.318	<150-0.33
KID.:	400	22.5	110.7	277.2	0.045	88.2	254.7	0.346	>150-0.30
	400	13.3	116.5	292.5	0.041	103.2	279.2	0.370	
	400	286.3	513.7	968.0	0.082	227.4	681.7	0.334	
	400	801.0	1531.9	2580.9	0.090	730.9	1779.9	0.411	
	250	1405.7	2279.4	3976.8	0.239	873.7	2571.1	0.340	
	400	43.3	88.1	199.3	0.038	44.8	156.0	0.287	
	400	321.4	488.1	1030.0	0.068	166.7	708.6	0.235	
#32	250	1041.9	1315.2	2098.5	0.172	273.3	1056.6	0.259	AVG.-0.30
A78-67	400	613.6	1054.0	2109.5	0.068	440.4	1495.9	0.294	<150-0.31
MYO.:	400	15.7	44.0	82.6	0.029	28.3	669.0	0.423	>150-0.26
	400	219.5	514.7	1043.8	0.061	295.2	824.3	0.358	
	250	266.0	737.6	2245.3	0.118	471.6	1979.3	0.238	
	400	142.4	182.6	478.0	0.057	40.2	335.6	0.120	
	400	276.2	421.7	632.7	0.061	145.5	356.5	0.408	
#32	250	1577.7	2654.8	3433.0	0.250	1077.1	1855.3	0.580	AVG.-0.46
A78-67	400	40.1	132.4	233.1	0.033	92.3	193.0	0.478	<150-0.46
KID.:	400	42.4	86.0	139.1	0.034	43.6	96.7	0.450	>150-0.45
	100	494.5	777.5	1369.8	0.358	283.0	875.3	0.323	
	250	1259.7	2344.9	3685.0	0.250	1085.2	2425.3	0.447	
#33	400	1067.7	1704.3	2834.9	0.097	636.6	1767.2	0.360	AVG.-0.48
A78-81	400	1199.5	1632.3	2394.9	0.112	432.8	1195.4	0.362	<150-0.47
MYO.:	400	1265.0	1665.3	2405.4	0.150	400.3	1140.4	0.351	>150-0.52

Patient	Mag.	L (mm²)	I (mm²)	M (mm²)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
	400	640.8	1382.3	2360.4	0.080	741.5	1719.6	0.431	
	400	384.7	743.4	1269.6	0.076	358.7	884.9	0.405	
	400	762.2	1113.0	1800.1	0.104	350.8	1037.9	0.338	
	400	53.2	333.6	473.3	0.056	280.4	420.1	0.667	
	400	188.3	1666.6	2357.5	0.198	1478.3	2169.2	0.681	
	400	267.8	1063.3	1367.0	0.102	795.5	1099.2	0.724	
#33	400	541.4	979.9	1637.8	0.095	438.5	1096.4	0.400	AVG.-0.51
A78-81	250	1441.4	3206.6	4177.3	0.204	1765.2	2735.9	0.645	<150-0.31
KID.:	400	32.0	80.4	196.7	0.042	48.4	164.7	0.294	>150-0.57
	250	1259.0	2538.7	3088.9	0.234	1279.7	1829.9	0.700	
	400	55.0	93.3	210.3	0.039	38.3	155.3	0.250	
	100	374.8	620.1	778.9	0.322	245.3	404.1	0.607	
	250	449.6	2225.9	3149.3	0.191	1776.3	2699.7	0.660	
	250	1794.3	3794.2	5223.5	0.220	1999.9	3429.2	0.583	
	100	407.4	726.7	1066.7	0.342	319.3	659.3	0.484	
#34	400	365.5	579.1	1023.4	0.057	213.6	657.9	0.32	AVG.-0.29
26021	400	56.3	95.3	195.9	0.022	39.0	139.6	0.28	<150-0.25
MYO.:	400	753.3	1071.7	1904.3	0.049	318.4	1151.0	0.28	>150-0.39
	250	323.2	456.8	952.1	0.110	133.6	628.9	0.21	
	100	360.6	605.3	984.3	0.279	244.7	623.7	0.39	
	400	377.8	600.8	1384.0	0.076	223.0	1006.2	0.22	
	400	467.2	765.1	1325.4	0.095	297.9	858.2	0.35	
	400	68.3	117.9	205.0	0.031	49.6	136.7	0.36	
	400	37.1	58.2	128.7	0.031	21.1	91.6	0.23	
#34	400	974.7	1349.9	2125.0	0.101	375.2	1150.3	0.33	AVG.-0.30
26021	400	266.6	368.7	723.3	0.066	102.1	456.7	0.22	<150-0.29
KID.:	400	1340.2	1707.8	2768.8	0.103	367.6	1428.6	0.26	>150-0.37
	400	801.7	965.5	1359.2	0.100	163.8	557.5	0.29	
	400	782.9	1275.8	2202.3	0.093	492.9	1419.4	0.35	
	400	1385.9	1712.2	2540.3	0.104	326.3	1154.4	0.28	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
	400	1046.6	1389.3	2099.4	0.127	342.7	1052.8	0.33	
	250	1352.8	1674.9	2364.6	0.199	322.1	1011.8	0.32	
	250	1080.2	1707.1	2600.6	0.182	626.9	1520.4	0.41	
	400	172.7	238.3	464.1	0.048	65.6	291.4	0.23	
#35	400	102.8	146.1	325.7	0.036	43.3	222.9	0.19	AVG.-0.22
26018	400	211.5	331.8	938.1	0.052	120.3	726.6	0.17	<150-0.22
MYO.:	400	54.2	74.8	134.4	0.031	20.6	80.2	0.26	>150-0.20
	400	76.9	104.7	186.8	0.035	27.8	109.9	0.25	
	250	514.0	671.6	1324.1	0.119	157.6	810.1	0.19	
	400	1223.7	1487.1	2443.3	0.108	263.4	1219.6	0.22	
	250	947.2	1316.4	2818.7	0.150	369.2	1871.5	0.20	
	400	163.0	230.7	396.9	0.041	67.7	233.9	0.29	
#35	400	72.6	105.8	269.6	0.038	33.2	197.0	0.17	AVG.-0.21
26018	250	1831.1	2806.6	4072.8	0.272	975.5	2241.7	0.44	<150-0.15
KID.:	250	1067.4	2040.7	4536.2	0.205	973.3	3468.8	0.28	>150-0.26
	400	224.1	314.3	724.9	0.079	90.2	500.8	0.18	
	100	955.7	1192.8	2818.5	0.547	237.1	1862.8	0.13	
	100	436.3	642.3	1486.3	0.412	206.0	1050.0	0.20	
	400	88.7	136.3	545.0	0.066	47.6	456.3	0.10	
#36	400	240.7	321.9	622.4	0.041	81.2	381.7	0.21	AVG.-0.21
26165	400	566.3	752.7	1714.2	0.069	186.4	1147.9	0.16	<150-0.22
MYO.:	400	204.4	286.3	491.9	0.044	81.9	287.5	0.28	>150-0.14
	400	275.7	365.4	864.7	0.059	89.7	589.0	0.15	
	400	386.5	487.5	1067.0	0.076	101.0	680.5	0.15	
	250	239.4	332.9	698.5	0.056	93.5	459.1	0.20	
	250	954.5	1254.2	3058.5	0.154	299.7	2104.0	0.14	
	400	528.3	740.3	1418.5	0.063	212.0	890.2	0.24	
	400	58.2	155.9	318.4	0.027	97.7	260.2	0.38	

Patient	Mag.	L (mm²)	I (mm²)	M (mm²)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
#36	250	853.5	1032.0	1810.7	0.164	178.5	957.2	0.186	AVG.-0.25
26165	100	2022.6	2363.3	4401.5	0.467	340.7	2378.9	0.14	<150-0.31
KID.:	250	672.7	831.5	1135.6	0.144	158.8	462.9	0.34	>150-0.17
	400	1198.7	1581.8	2268.2	0.119	383.1	1069.5	0.36	
	400	45.5	63.6	128.3	0.034	18.1	82.8	0.22	
#37	400	105.4	158.4	286.5	0.039	53.0	181.1	0.29	AVG.-0.26
16150	400	459.7	565.3	1017.6	0.055	105.6	557.9	0.19	<150-0.26
MYO.:	400	310.4	676.2	1468.9	0.067	365.8	1158.5	0.32	>150- --
	400	185.5	333.0	637.4	0.055	147.5	451.9	0.33	
	400	122.1	236.0	551.0	0.046	113.9	428.9	0.27	
	400	755.4	1070.3	1981.7	0.073	314.9	1226.3	0.26	
	100	152.7	212.0	472.3	0.112	59.3	319.6	0.19	
#37	250	2238.4	3202.8	4883.3	0.264	964.4	2644.9	0.36	AVG.-0.27
26150	400	40.3	58.3	115.6	0.038	18.0	75.3	0.24	<150-0.26
KID.:	400	785.3	1053.3	1910.3	0.104	268.0	1125.0	0.24	>150-0.36
	400	1328.8	1657.6	3130.7	0.116	328.8	1801.9	0.18	
	400	691.2	851.6	1754.3	0.087	160.4	1063.1	0.15	
	400	52.5	105.4	285.0	0.037	52.9	232.5	0.23	
	400	50.0	92.5	141.4	0.035	42.5	91.4	0.46	
	400	77.3	112.0	232.9	0.032	34.7	155.6	0.22	
	400	858.0	1278.6	2174.9	0.124	420.6	1316.9	0.32	
#38	400	100.6	190.9	326.2	0.035	90.3	225.6	0.40	AVG.-0.36
A78-75	250	361.7	685.0	1274.8	0.095	323.3	913.1	0.354	<150-0.36
MYO.:	400	462.8	846.9	1653.7	0.086	384.1	1190.9	0.323	>150- --
	400	170.9	394.4	744.7	0.058	223.5	573.8	0.390	
	400	53.4	110.9	193.0	0.024	57.5	139.6	0.412	
	400	74.9	143.8	215.3	0.029	68.9	140.4	0.491	
	400	63.0	182.1	406.2	0.036	119.1	343.2	0.347	
	400	452.4	909.4	2112.3	0.051	457.0	1659.9	0.275	
	400	126.5	282.9	571.5	0.046	156.4	445.0	0.351	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
	400	163.1	288.2	538.9	0.037	125.1	375.8	0.333	
	400	1005.6	1581.7	2575.7	0.089	576.1	1570.1	0.367	
	400	122.2	292.1	644.1	0.057	169.9	521.9	0.326	
#38	250	1618.6	2481.4	4351.5	0.303	862.8	2732.5	0.316	AVG.-0.28
A78-75	250	936.8	1125.8	2077.5	0.126	189.0	1140.7	0.166	<150-0.28
KID.:	400	555.9	784.7	1196.0	0.100	228.8	640.1	0.357	>150-0.27
	100	378.2	557.8	992.4	0.253	179.6	614.2	0.292	
	100	487.4	786.4	1379.3	0.228	299.0	891.9	0.335	
	400	78.6	163.2	323.2	0.048	84.6	244.6	0.346	
	400	35.6	121.9	388.1	0.037	86.3	352.5	0.245	
	250	1550.1	1829.7	3352.3	0.175	279.6	1802.2	0.155	
#39	400	1266.9	1691.9	2434.4	0.150	425.0	1167.5	0.364	AVG.-0.32
A78-47	250	707.0	1223.7	1866.8	0.137	516.7	1159.8	0.446	<150-0.33
MYO.:	400	88.3	191.7	405.9	0.051	103.4	317.6	0.326	>150-0.28
	400	179.4	397.2	829.9	0.068	217.8	650.5	0.335	
	250	2084.8	2492.0	4165.4	0.222	407.2	2080.6	0.196	
	400	534.0	728.3	1417.5	0.096	194.3	883.5	0.220	
#39	250	1058.7	1464.7	2420.0	0.191	406.0	1361.3	0.298	AVG.-0.36
A78-47	250	748.9	1388.6	2170.9	0.153	639.7	1422.0	0.450	<150-0.36
KID.:	400	31.7	89.4	178.8	0.031	57.7	147.1	0.392	>150-0.40
	100	1421.6	1982.2	2635.8	0.440	560.6	1214.2	0.462	
	250	843.2	1104.4	1869.0	0.118	261.2	1025.8	0.255	
	400	629.6	991.3	1742.7	0.098	361.7	1113.1	0.325	
#40	400	385.6	509.5	873.7	0.060	123.9	488.1	0.25	AVG.-0.25
25906	400	982.1	1080.4	1433.1	0.100	98.3	451.0	0.22	<150-0.25
MYO.:	400	66.2	97.6	156.5	0.030	31.4	90.3	0.35	>150- --
	400	46.4	76.3	180.5	0.040	29.9	134.1	0.22	
	400	46.6	54.3	84.1	0.020	7.7	37.5	0.21	

Patient	Mag.	L (mm^2)	I (mm^2)	M (mm^2)	Arterial Dia (mm)	I-L	M-L	$\frac{I-L}{M-L}$	AVG., <150, >150
#40	400	25.8	33.0	75.8	0.020	7.2	50.0	0.144	AVG.-0.26
25906	400	29.8	40.3	85.8	0.020	10.5	56.0	0.19	<150-0.25
KID.:	250	966.2	1216.5	1700.7	0.140	250.3	734.5	0.34	>150-0.29
	100	459.4	547.4	820.8	0.230	88.0	361.4	0.24	
	250	866.6	1213.6	1702.8	0.170	347.0	836.2	0.41	
	400	27.5	71.1	188.1	0.050	43.6	160.6	0.27	
	100	477.7	532.9	846.5	0.181	55.2	368.8	0.15	
	400	31.0	40.4	94.6	0.030	9.4	63.6	0.15	